Australasian Plant Conservation

BULLETIN OF THE AUSTRALIAN NETWORK FOR PLANT CONSERVATION

VOLUME 14 NUMBER 4 • MARCH - MAY 2006

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Fire season and intensity: implications for plant conservation
Burning the fringe: managing fire in an outer suburban vegetation remnant
Varying fire regimes to promote fungal diversity across the landscape
Can the Port Jackson Fig tolerate fire?
And much much more.........

SPECIAL THEME: FIRE FOR CONSERVATION

This issue

Regular Features

Australasian Plant Conservation is produced by the ANPC Inc. with assistance from the Australian National Botanic Gardens.

Australasian Plant Conservation is printed on recycled paper.

ISSN 1039-6500

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ANPC Inc. Mission Statement

"To promote and improve plant conservation"

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Australasian Plant Conservation is a forum for information exchange for all those involved in plant conservation: please use it to share your work with others. Articles, information snippets, details of new publications or research, and diary dates are welcome. **The deadline for the June-August 2006 issue is Friday 9 June.** The June-August issue will be on the special theme of 'Conservation of Seed Resources', however general articles may also be accepted.

Authors are encouraged to submit images with articles or information. Please submit images as clear prints, slides, drawings, or in electronic format. Electronic images need to be at least 300 dpi resolution, submitted in at least the size that they are to be published, in tif, jpg or gif format.

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Front cover: Fire in a jarrah forest in south-western WA. Photo: Lachie McCaw.
Cover design: Siobhan Duffy.
Printed by: Pirion, Canberra.

President's Report

Judy West

Centre for Plant Biodiversity Research, CSIRO Plant Industry

In mid February the National Committee of the Australian Network for Plant Conservation held a planning day addressing a number of matters to assist in developing the Network's future directions. The diversity of skills and experiences of our new committee became evident throughout the discussions, contributing to a very successful day with interchange of ideas stimulating some lateral thinking and resulting in considerable progress. The major point of consideration was the update and development of the strategic vision for ANPC. This document is travelling through a number of iterations, but we anticipate the draft strategic plan will be made available to ANPC members for your input and comment in the next couple of months. It will be of no surprise to those familiar with ANPC activities that one of the main themes underpinning the strategic thinking is ANPC's role in fostering two-way interchange of information between researchers and conservation practitioners. I feel encouraged by the active participation of the committee members and I'm sure the organisation will benefit from this investment in some dedicated strategic planning.

In this edition of *Australasian Plant Conservation* we focus on the theme of fire and conservation, with contributions ranging from the science of burning to the practicalities of using fire for conservation in small urban remnants. The issue opens with a plea for consideration of season and intensity when planning fire regimes (Clarke, Knox and Williams). Encouragingly, projects are underway across Australia to scientifically test the effectiveness of different styles of 'burning for biodiversity'. In the Top End, Andersen and co-workers describe an ambitious project to foster understanding of the effects of fire regimes on biodiversity in savanna landscapes. For forests in the Walpole area of south-west WA, Burrows introduces a study about fine-grained fire mosaics in regard to biodiversity and the reduction of severe wildfires. On the other side of the continent, Hammill and Bradstock describe a landscape-scale study of plant diversity, fire and climate in the Greater Blue Mountains World Heritage Area.

The article by Conroy and co-workers about the Hotspots Fire Project epitomises what ANPC is all about – 'translating science into a practical management framework for land managers and regional communities'. This project involves research, training and education on use of fire in managing biodiversity while at the same time preserving lifestyles.

Research in particular ecosystems is leading to specific management recommendations about fire. For Cumberland Plain Woodland in Western Sydney, Watson and Morris predict that variable fire intervals will maintain much of the landscape, and keep fuel loads compatible with property protection. Wong and co-authors consider fire as an alternative management tool to grazing in the native grassland of northern Victoria. For a bush remnant in outer suburban Melbourne, Coates reports on the practical experience of applying and monitoring fire for management of plants and animals.

Fire affects animals and fungi as well as plants. Robinson describes recent research on forest macrofungi indicating that a mosaic of fire ages and intensities maximises fungal diversity.

Four articles focus on fire and its effects on individual plant species – in New South Wales, *Ficus rubiginosa* (Cameron) and *Haloragis exalata* (Miles and Cameron), In New Zealand, *Nothofagus solandri* var. *cliffortioides* (Ledgard and David), and in Victoria, *Pimelea spinescens* subsp. *spinescens* (Thomas).

The final two articles on the fire theme present contrasting views for (Jurskis) and against (Schultz) frequent burning.

The articles on fire in this issue show that whilst fire is still a topical issue, there is a promising amount of research underway providing a scientific underpinning to 'burning for biodiversity', and at the same time land managers are accumulating practical experience in the use of fire for conservation that can usefully inform the research.

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Disadvantages:

- it's harder to leave in your work tea-room for others to peruse (!).

Fire season and intensity: implications for plant conservation

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Fire regimes

Fire is pervasive in Australian ecosystems but surprisingly we know little of its conservation implications when it occurs in different seasons and at different fire intensities. From tropical north to the temperate south most vegetation in Australia burns when it is dry and there is a source of ignition. Even the rainforests of eastern Australia are known to burn after prolonged droughts such as occurred in 2001-2002 (Marrinan *et al.* 2005). Much of the popular media focuses upon the tragic events of these fires, and when reporting on biodiversity consequences, again the focus is on the severity of the event rather than the fire regime.

Most conservation managers realise that it is not the fire event *per se* but the cumulative impact of fires over time that drives changes in biodiversity. Such a history of fire is termed the fire regime and is often simplified into three key interacting components: frequency, intensity and season of fire. It is well known that short intervals between fires can drive plant populations to local extinction, especially when species are slow to mature and their seed banks are not persistent. Less well known are the consequences of season and intensity of fire but recent experimental studies have revealed the risks to plant biodiversity from inappropriate regimes.

Why is season and intensity of fire important?

Fuel accumulation and flammability are influenced by weather conditions and hence determine the season and intensity of fires. In turn, fire season may control plant life cycles because: 1) heat and smoke regulate seed dispersal and dormancy, 2) soil temperature and rainfall control post-fire germination and growth, 3) seed reserves fluctuate seasonally, and 4) seasonal activity of competitors, predators and pathogens influence seedlings survival after fire. A good example of these effects is the contrast between recruitment of *Acacia* species in 'wheat fields' following summer fires in 2002 in eastern Australia compared to adjacent areas of autumn hazard reduction where recruitment is less pronounced. It is likely that these patterns are produced not only by differences in fire intensity breaking seed dormancy, but also because of seasonal effects on germination and growth of seedlings and the action of predators and competitors which vary seasonally.

Region and season of burn

Fires tend to burn less intensely during the cooler months in south-eastern Australia because fuel is less flammable. Under these conditions fire intensity is attenuated and consequently numerous studies have shown reduced germination and emergence of hard-seeded species. Researchers have artificially increased the intensity of cool season fires and watered after fire but still seedlings fail to emerge. Even species, which readily germinate without heat or smoke often fail to emerge after winter fires because soil temperatures are too low for germination. All seeds then appear prone to seed predators and pathogens, hence few seeds emerge the following spring even if rainfall is plentiful. This is the reason why in the cool upland areas of eastern Australia higher intensity spring fires followed by summer rainfall are likely to produce seedling recruitment (Knox and Clarke in press).

In the winter rainfall regions of south-western Australia and in South Africa seedling emergence of Proteaceae shrubs has also been shown to be strongly affected by fire season. In these Mediterranean-type climates spring fires adversely affect recruitment because seeds fail to establish over the long dry summer. Both physiological drought and seed predators are thought to limit seedling recruitment. So in these systems autumn burns followed by winter rain enhance seedling recruitment of many shrubs.

In contrast to the temperate regions of Australia the tropics more commonly burn during the winter dry. Here researchers have shown that season of fires plays a crucial role in breaking the dormancy of species. In these systems late dry season fires enhance seedling recruitment because they are more intense and more seed is available at that time of year (Williams *et al.* 2005a & b). Whilst some species may benefit from late season fires, others, such as rainforest species, may be adversely affected because these fires are more intense. Hence 'early season' patchy fires have been used as a management tool for reducing risk to vulnerable species and habitats.

Balancing the risks

Understanding the risk to plant conservation associated with fire regimes requires a knowledge of the way plant species respond to fire regimes and there is still much to do for researchers. Recent books on managing plant

biodiversity emphasise the role of variability in frequency, intensity and season to maintain processes that allow species to persist (see Bradstock *et al.* 2004). Season of fire has emerged as an important factor but the extent to which managers of biodiversity can modify regimes to reduce risk to species may be limited. This is because even prescribed burns can potentially threaten life and property; hence the overriding importance to control and contain fires. Both theory and evidence show that plant populations decline and local extinctions are possible when repeated fires occur in seasons when people are more likely to use prescribed burning ('early season' burns). Conversely, some species will be favoured by regular burning at one time of the year at low fire intensity. It is therefore important in areas where prescribed burning is common that some variability in the timing and intensity of fires be introduced into management plans.

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Burning for biodiversity in the Top End

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Introduction

The vast majority of bushfires in Australia occur in the savanna landscapes of the tropical north, where on average 300,000 km^2 are burnt each year. This part of Australia is primed for regular fire because of its monsoonal climate – grasses grow tall and thick in the summer wet season, and then become highly flammable during the dry season. Fires in tropical woodlands are different from those in temperate forests of southern Australia, being confined to the grass layer, and rarely, if ever, burning the canopy. The relatively low fire intensities, combined with a sparse population, mean that most fires pose little threat to people and property. Rather, fire is used in a positive way for habitat management, including by Aboriginal people wishing to maintain their customary land management practices. Frequent fire is fundamental to the northern Australian environment, and without it we would lose much of our savanna biodiversity.

Bushfires are especially prevalent in the monsoonal tallgrass landscapes of the Top End of the NT and the northern Kimberley region of WA, half or more of which are burnt each year. Most of the fires are lit by people, including conservation managers, pastoralists and traditional Aboriginal land owners. There have been severe disruptions to traditional Aboriginal burning practices over the past 50 years, resulting in marked changes in regional fire regimes. The ecological implications of these changes are yet to be firmly established, but alarming population declines in various plant and animal species have been attributed to them.

More broadly, the effects of different fire regimes on savanna biodiversity remain a matter of considerable scientific debate. Such scientific uncertainty is accompanied by a high degree of public confusion and lack of understanding of the importance of fire in northern Australian landscapes. Most visitors and residents alike come from a temperate background where fire is viewed as a destructive agent to be feared, rather than as an important tool for landscape management.

To help address this challenge, the Bushfire Cooperative Research Centre has established the 'Burning for Biodiversity' project, involving CSIRO and collaborators in the Top End. The project aims to enhance our knowledge of the effects of different fire regimes on biodiversity and ecological function, to improve fire management protocols for biodiversity conservation, including more effectively engaging with Aboriginal people, and to increase public awareness and understanding of the role of fire in northern Australia.

A new fire experiment

Research on fire in northern Australia has traditionally focused on fire intensity, comparing relatively low intensity fires occurring early (May/June) during the dry season (as extensively lit by conservation managers) with higher intensity wildfires occurring late (September/October) in the dry season. However, results from CSIRO's recently completed landscape-scale fire experiment at Kapalga in Kakadu National Park indicate that fire frequency, and more particularly time since fire, is far more important than

Figure 1. Lighting an experimental fire as part of the 'Burning for biodiversity' fire experiment at the Territory Wildlife Park near Darwin. Photo: Barbara McKaige

previously recognised (Andersen *et al.* 2005). There is a pressing need for further research on the interactive effects of fire intensity and frequency on ecological function and conservation management in northern Australia.

As part of the Burning for Biodiversity project, a new fire experiment has been established at the Territory Wildlife Park near Darwin, focussing on the importance of fire frequency and time-since-fire. This collaboration between the Northern Territory Government, CSIRO, and Charles Darwin University features 18 hectare-sized research plots, each subject to one of six experimental fire regimes (Fig. 1). Researchers are studying fire behaviour and its effects on biodiversity and ecological function. Botanical research focuses on grass-layer dynamics, patterns of tree growth, mortality and seedling recruitment, and interactions between fire and grazing by wallabies.

Aboriginal fire management of tropical wetlands

Aboriginal Australians successfully lived with and used landscape fire for tens of thousands of years prior to European settlement. Throughout most of southern Australia, Aboriginal fire management has long been consigned to history, and the lessons learned from millennia of fire experience have been lost forever. However, this is not the case in the north, where much of the area (for example, about half of the Northern Territory) is Aboriginal land, and in many cases fire management remains an integral part of Aboriginal life. Although Aboriginal fire management has been severely disrupted, much of the traditional knowledge relating to fire management has been retained, and the opportunity still exists to re-apply such knowledge to landscape management.

As part of 'Burning for Biodiversity', the Bushfire CRC is working with a family of traditional owners in Kakadu National Park to examine the biodiversity and cultural benefits of Aboriginal fire management as it is re-applied to floodplains associated with the South Alligator River. Preliminary work suggests that the re-application of traditional fire management dramatically enhances biodiversity and the cultural values of these wetlands for Aboriginal people (Fig. 2).

This study serves as an internationally significant model for integrating Indigenous and Western knowledge systems to achieve positive outcomes for both traditional resource use and the conservation of biodiversity. It involves collaboration between CSIRO, Parks Australia North, and the Environmental Research Institute of the Supervising Scientist.

Fire education

The Burning for Biodiversity project also has a strong emphasis on the delivery of information and learning products for public and higher education. The project team is developing a range of information products covering all aspects of the role of fire in the management of conservation landscapes in northern Australia, for fire managers and the general public. A dedicated walk-through demonstration site is being established at the Territory Wildlife Park, providing visitors with a hands-on experience of fire. In addition, the Bushfire CRC, Tropical Savannas CRC, CSIRO and Charles Darwin University have joined forces to produce the on-line university course 'Fire Ecology & Management in Northern Australia', which tackles a wide range of complex ecological, social, political and historical aspects of fire management across northern Australia. The course is the first of its kind, and won the 2005 National ASCILITE (Australasian Society for Computers in Learning in Tertiary Education) Award for Educational Design & Technology in Tertiary Education.

Figure 2. Appropriate fire management can markedly increase biodiversity and Aboriginal cultural resources in wetlands of Kakadu National Park. Photo: Sandra McGregor

Conclusion

Fire management in northern Australia presents challenges quite different to those occurring in southern Australia, with an emphasis on active landscape management rather than fire suppression and control. Frequent fire is essential for maintaining conservation values, but details of the fire regimes required to conserve the full range of biodiversity values are poorly understood. Such scientific uncertainty only compounds public confusion over the role of fire in northern Australia, and limits our ability to meet the aspirations of Aboriginal people wishing to maintain customary burning practices. We are hopeful that the Burning for Biodiversity project will produce positive outcomes in terms of:

- enhanced understanding of the effects of different fire regimes on biodiversity and ecological function;
- improved fire management protocols for biodiversity conservation, including more effective engagement of Aboriginal people; and
- increased public awareness and understanding of the role of fire in northern Australia.

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Burning for biodiversity: investigating fine grain fire mosaics in south-west Australia

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Fire management, including prescribed burning based on scientific knowledge, is fundamental to the conservation of biodiversity and the protection of life and property in the fire-prone bushland environment of south-west Western Australia. There is scientific evidence supporting that, within ecological limits, fire diversity can benefit biodiversity at the landscape scale (e.g. Bradstock *et al.* 2002, Abbott and Burrows 2003). There is also growing opinion that a fine-grained mosaic of patches of vegetation representing a range of post-fire seral stages (fire intervals), burn seasons and fire intensities will provide diverse habitat opportunities and can also contribute significantly to reducing the severity (size and intensity) of damaging wildfires.

The Walpole Fire Mosaic Project is designed to test these notions, and is an example of active adaptive management to improve fire management and biodiversity outcomes in south-west WA. It is a collaborative landscape-scale trial involving scientists and practitioners from the Department of Conservation and Land Management, scientists and students from the University of Western Australia, Murdoch University and the University of Queensland, and scientists associated with the national Bushfire Cooperative Research Centre.

Specifically, the project aims to determine a) whether a fine-grained fire-induced habitat mosaic can be created by the regular and targeted re-introduction of fire into the landscape (patch-burning) and b) whether this mosaic promotes biodiversity conservation through space and time. This does not mean frequently burning out the landscape, but rather, attempting to create a mosaic by regularly burning relatively small patches (perhaps up to several hundred hectares) across the landscape. The trial area covers about 6,000 ha of forest, wetlands, woodlands and healthlands located some 35 km north of the town of Walpole, on the south coast of WA. The patch-burning is carried out using a helicopter to deliver incendiaries to create burnt patches in strategic locations across the landscape. The number, size and location of the burnt patches will be managed by controlling the ignition pattern, by burning under different seasonal conditions including when strong moisture (hence flammability) gradients exist across the landscape, by utilizing natural barriers to fire spread such as low fuel areas created by previous patch-burning, and by choosing the appropriate weather conditions under which to conduct the patch-burning.

Because of the variable nature of vegetation at the landscape scale, some patches will probably burn more frequently than others – part of the study will be to determine which parts of the landscape burn at what intervals and under what conditions. The resulting shifting mosaic will be mapped through time using the latest satellite mapping technology. The response by elements of the biota, including mammals, reptiles, vascular plants, birds, cryptogams and fungi, will be monitored by a network of sampling grids. We are expecting that in time, the landscape will consist of a stable mosaic of relatively small patches of vegetation that vary in time since fire from recently burnt to long unburnt. Monitoring will also be carried out at two other reference sites – fire will be excluded from one of these sites, and the other site will experience the fire regime in accordance with existing management plans.

At this stage, the biodiversity monitoring grids have been installed and assessed. The first patch-burn operation was conducted by helicopter in mid-January, under mild weather conditions. While it is early in the life of the project, which is expected to run for at least 10 years, the indications are very promising. We will have a more accurate picture once the satellite imagery has been processed and analyzed, but the first patch-burn trial appears to have burnt about 5-7% of the landscape with relatively small burnt patches ranging in size from a few hectares to several hundred hectares.

An important element of this approach to fire management is that the timing and extent of future re-introductions of fire into the landscape will be determined by the consequences and outcomes of previous fires, such as how much and which parts of the landscape burnt previously, rather than being determined well in advance, based on measures such as time since last fire.

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Patch-burning to create a fine grained habitat mosaic in forests in south-west Western Australia. Photo: Neil Burrows

Meandering in the mountains: a landscape-scale study of plant diversity, fire and climate

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Background

There is currently much discussion about how climate change will affect effect natural ecosystems (Hughes 2003, NSW Nature Conservation Council 2005). In the fire-prone landscapes of the Sydney Region, climate change predictions point to an increase in the number of hot days and the severity of droughts. Consequently, fires originating from both natural (lightning) or anthropogenic (arson) ignitions may become more frequent, more intense and larger in size.

Here, we introduce a three-year research project (commenced in May 2005) in which we are seeking to understand how future climate and fire regimes may affect plant communities in the Greater Blue Mountains World Heritage Area (GBMWHA). The GBMWHA spans over a million hectares and seven National Parks: Yengo, Wollemi and Gardens of Stone, Blue Mountains, Kanangra-Boyd, Nattai and Thirlmere Lakes. The area is dominated by an extensive sandstone plateau that has been eroded by water over the last 20 million years, forming spectacular escarpments and deep v-shaped valleys. The greatest concentration of eucalypt diversity in Australia (91 species) occurs there, along with many endemic and rare or threatened plant and animal species.

Our research, funded by the NSW Environmental Trust (with in-kind contribution of DEC), is a landscape-scale study of plant diversity in relation to major rainfall, temperature and fire history patterns. In particular, we will examine whether the fire regimes have a similar influence on vegetation composition in different climate zones across the GBMWHA.

Rationale for the research

The 'biodiversity fire regime thresholds' used in fire management strategies for conservation reserves in the

Sydney Region are largely based on information from studies in near-coastal or Cumberland Plain landscapes (eg. Bradstock and Kenny 2003). It seems that there have been no systematic studies of fire effects on vegetation in the greater Blue Mountains area. While much of the sandstone country in the mountains supports plant communities similar to those nearer the coast (ie. sclerophyll shrublands, woodlands and forests), there are major climate gradients in the mountains not represented near the coast. These gradients influence the distribution of species (Keith and Benson 1988) and they may also influence how plant communities respond to fire. With these factors in mind, we decided to focus our research at a landscape scale, to take advantage of natural gradients in climate and, in particular, to consider possible interactions between the effects of climate and fire on plant diversity.

Field survey design and methods

Within the GBMWHA, average temperatures generally decrease from east (~100 m above sea level) to west (~1100 m above sea level) in association with altitude. Rainfall patterns do not necessarily follow the same trend, with both wetter and drier areas occurring across a wide range of altitude/temperature zones. We have identified areas representing combinations of three rainfall (1200, 1000, 800 mm per annum) and three temperature (average annual 11, 14, 18°C) zones from about Blackheath in the south-west to Bulga in the north-east.

Within each climate zone, vegetation composition is being surveyed at sites with different fire histories. Fire maps recorded by the NSW National Parks & Wildlife Service (now part of DEC) have been used to find sites that have been affected by between one and six fires in the last four decades. We are using satellite images and aerial photographs to determine different levels of fire intensity at particular locations, with intensity being characterised in terms of crown fire or understorey fire (Hammill and Bradstock, in press). Fire intensity is important because it influences how plants recover after fire (Morrison 2002).

The survey design can be described as a 'natural experiment' since we are using climate and fire history patterns already present in the landscape. Floristic data are being collected using a nested quadrat method (Morrison *et al.* 1995). With more than 100 sites to survey, we are currently about one-third the way through the field component of the project.

Some outcomes of the research:

- we hope to detect whether there are existing patterns in vegetation composition related to both climate and fire history;
- we will use the concept of plant 'functional groups' (groups of species that respond to fire in a similar way, e.g. resprouters or seeders) to predict how plant communities may respond to future fire and climate regimes. (This links with Bushfire CRC and other projects concerned with climate change and fire behaviour); and
- we also aim to provide information to assist fire management and conservation planning in the GBMWHA.

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Left: Fire in sclerophyll woodland/open-forest vegetation typical of the Blue Mountains. Photo: Tony Auld. Right: Ecologist Sonya Ku assisting with vegetation survey in the Putty Road area, February 2006. Photo: Kate Hammill

The Hotspots Fire Project: translating science into management for landholders and communities in NSW

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Living with fire

Triggered by lightning strikes and traditionally used by Aboriginal Australians, fire has shaped the diversity and character of Australian landscapes for millions of years. Many plant and animal species have evolved strategies for coping with fire, and some species have developed ways to take advantage of the opportunities it creates. Since fire is such a powerful disturbance force, changes in fire patterns can quickly influence which species (and reproductive strategies) will persist in an area and which won't.

For many land managers and communities, the responsible use and management of fire represents an ongoing challenge. Eliminating fire is neither a practical nor an ecological solution. We live in fire prone landscapes. Meeting the challenges associated with fire requires effective planning and collaboration within communities, between agencies and across tenures.

What's the Hotspots project about?

This innovative pilot project looks at how fire can be managed to conserve biodiversity and other natural assets – as well as the lifestyle and land uses we value. Through a coordinated program of research, training and education initiatives, Hotspots is translating science into a practical management framework for land managers and regional communities.

Funded by the New South Wales Environmental Trust, the Hotspots Fire Project is delivered by the Nature Conservation Council of NSW. Regional partners include the NSW Rural Fire Service, NSW Department of Environment and Conservation, the Catchment Management Authorities, and NSW Farmers Association.

Like many natural processes, the relationship between vegetation and fire regime is complex. However there are some simple principles that emerge in the following story about fire in a particular community.

Plant responses to fire frequency and fire extent in grassy vegetation

Grassy forest and woodland in the Northern Rivers region is used extensively for pasture and has a strong historic association with frequent burning. Fire frequency affects the balance between woody species and grasses. Frequent burning tends to produce open, grassy landscapes, whereas in places where fire has been excluded or is rare, shrubs and young trees tend to increase in numbers.

Currawinya landholders at a Hotspots workshop. Photo: Waminda Parker

Plant diversity in grassy forest and woodland is concentrated in the ground layer. Here, tussock-forming grasses such as Kangaroo Grass (*Themeda* sp.), Barbed Wire Grass (*Cymbopogon refractus*) and Native Sorghum (*Sorghum leiocladum*) dominate the ground layer. Smaller grasses and herbs grow in the spaces between these tussocks. Fire burns the dense tussocks back, making space for the smaller species. Many grasses and herbs flower rapidly after fire, producing seeds which germinate while gaps between resprouting grass tussocks are still available. Thus fire provides a way for shrubs, large grasses, small grasses and herbs to live together.

Where fire has been excluded from grassy areas, shrubs – including Lantana (an environmental weed) – can increase to the point where grasses and herbs are shaded out. Heavy litter which accumulates as time goes by after a fire may also leave little room for small ground layer species.

Research suggests some ground layer grasses and herbs grow best in open patches away from trees and shrubs; these species may be lost if open patches disappear. Changes may occur most rapidly in areas where rainfall is high and soils are fertile.

Varying fire frequency over time and space is important to maintain biodiversity. In grassy woodland and forest understoreys, patchy fires play a vital part in ensuring enough space for all plant species including shrubs, grasses and herbs.

Ecologically appropriate fire regimes

The Hotspots team works with a diverse range of people interested in fire – from landholders and rangers to fire fighters, ecologists, government agencies and others. Not surprisingly, we are tapping into the local knowledge held by leading scientists, park managers, and other experts on the fire and biodiversity front. Project ecologist, Penny Watson is working in collaboration with other fire ecologists to examine:

- the ecological concepts which underpin understanding of the role of fire in Australian ecosystems;
- fire regimes compatible with the conservation of biodiversity in vegetation communities at a regional scale, in the light of ecological concepts and local research; and
- the relationships between fire, grazing and landscape productivity.

Translating science into management

With the help of experienced ecologists and science communicators the team is creating a set of booklets and other resources. Everyday language is used to explore the relationship between living things, fire and the surrounding environment. The resources are a great way for landholders to access information about ecological fire regimes and individual property fire management planning.

The Hotspots team then ensures this information reaches landholders through a series of practical workshops. Workshops improve the capacity of communities to work together to manage fire, and offer a hands-on approach to fire management planning within and between properties. This approach addresses the goals of different land uses such as farm production and biodiversity conservation.

Hotspots is trialing its approach in four regions of New South Wales: the Northern Rivers, Southern Rivers, Hawkesbury-Nepean and Central West.

The Northern Rivers region pilot

A pilot program of introductory workshops was held in the Northern Rivers region in the winter/spring of 2005. The workshops generated a huge amount of interest, especially once word got out via the landholder ‘bush telegraph’. Over 130 landholders and community representatives participated.

Top: Recently burnt Kangaroo Grass Themeda *sp.*
Photo: Gillian Basnett.
Bottom: Tussock forming Kangaroo Grass Themeda *sp.*
Photo: Waminda Parker.

Each of the workshops was held in a different social community (from peri-urban to large land holdings in excess of 10,000 ha), in different landscapes (from coastal dunes to the gorges of the Northern escarpment), and in differing vegetation communities (from heathland to rainforest).

The one-day workshops provided an introduction to ecological fire regimes within the context of local native vegetation. Each workshop also addressed a different suite of local issues, including large-scale wildfires at Currawinya in the Upper Clarence Catchment, fuel loads

in State Forest near Glen Innes, issues associated with grazing and timber production in Tallewudjah (Lower Clarence), and protection of dwellings immediately adjacent to National Park at Wooleweyah.

Experts were on hand from state agencies such as the Rural Fire Service, NSW Forests, National Parks, and Northern Rivers Catchment Management Authority. Local ecologists, landholders and members of the Rural Fire Brigades provided additional insights and local expertise.

Conclusion

Through a series of steps that test, refine and expand the project materials and methods, the Hotspots fire project is developing a framework consistent with the NSW political and regulatory environment, and a model for ongoing training and education in fire ecology and fire management planning at the property level. Based on the positive feedback received so far from the regions where it has been tested, the project looks set to offer a framework to other catchment management regions across New South Wales.

Effects of fire on vegetation in Western Sydney's endangered Cumberland Plain Woodland

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Although the importance of fire management for biodiversity conservation is increasingly being recognised, little is known about the relationship between fire regimes and plant diversity in Australia's temperate grassy woodlands. Over the past four years we have attempted to address that gap for the woodlands of Western Sydney's Cumberland Plain.

Cumberland Plain Woodland (CPW), like most of the ecosystems endemic to the Western Sydney basin, is listed as endangered—only 10% remains, in scattered remnants. CPW grows on shale-based clay soils, receives approximately 800 mm of rainfall annually, is subject to hot summers and frosty winters, and hosts a species complement which has more in common with the grassy woodlands of the Western Slopes than with nearby shrubby sandstone woodlands. Three eucalypts are abundant: *Eucalyptus moluccana* (Grey Box), *E. tereticornis* (Forest Red Gum), and *E. crebra* (Narrow-leaved Ironbark). Shrubs include *Bursaria spinosa* (Bursaria, or Australian Blackthorn) and leguminous species. The ground layer consists of grasses interspersed with forbs.

Our research indicated that fire frequency profoundly affects both CPW composition and structure.

Shrubs

The influence of fire cycles was most readily apparent in the shrub layer. A survey in CPW remnants with differing fire histories found a high abundance of Bursaria in sites where fire frequency was low (sites that had been unburnt for at least 20 years prior to a recent fire), to the point where it dominated much of the landscape. Sites in the high fire frequency category (most fire intervals between one and three years) and moderate category (most intervals between four and 10 years) all had some Bursaria thickets, but much of the landscape was open and grassy. Other native shrubs, particularly obligate seeders (species whose adults are killed in a fire and rely on regeneration from seed), were significantly more abundant in sites burnt once or twice a decade than in either low or high fire frequency sites.

The relatively low abundance of obligate seeders in very frequently burnt sites is easily explained: if a second fire occurs before these species have grown sufficiently to set seed, then only ungerminated seed from before the first fire will be available to keep them in the community. In low fire frequency sites, competition from resprouting Bursaria may have played a role in the reduced abundance of other native shrubs. Unlike most other CPW shrubs, Bursaria plants can establish between fires, a characteristic which gives them a decided advantage in long unburnt areas. Obligate seeders on the Cumberland Plain mature rapidly, flowering by three or four years post-fire. Some appear to be short-lived. Once a generation of fire-cued obligate seeders dies, the population exists only as soil-stored seed. Seeds will germinate after the next fire, but may decay if the interval between fires becomes too long.

Ground Layer

The main effect of fire frequency on the ground layer concerned *Themeda australis* (Kangaroo Grass). It dominated high and moderate fire frequency sites, but not those where fire frequency was low. These findings echo those from Victorian grasslands, where *Themeda* has been found to decline in the absence of fire (Lunt and Morgan 1999; Morgan and Lunt 1999). A study focused on woodland microhabitats found no evidence of a direct

Left: Kangaroo Grass flowering in frequently burnt Cumberland Plain Woodland at Holsworthy, twelve months after a fire. Photo: Penny Watson.
Right: Bursaria-dominated landscape at Orchard Hills 2.5 years after a fire; no fire had occurred here for at least 30 years prior to this burn. Photo: Venesa Brusic

effect of fire frequency on ground layer species richness or composition in CPW, although low replication and stratified sampling may have obscured effects. However open patches, patches around trees and patches under Bursaria varied significantly in species composition. Thus fire frequency is likely to affect ground layer composition in CPW indirectly, through its influence on the shrub layer/ ground layer species with a preference for open areas will decline as Bursaria density increases.

Trees

Fire frequency did not significantly affect adult tree density, adult tree basal area, or the density of suppressed seedlings or saplings. Trends suggest frequent fire may be associated with an increased density of juveniles, but also with a decrease in the number of saplings 'getting away' into the canopy.

Exotics

Woody exotics were more abundant in low fire frequency sites than in areas which had burnt at least once a decade. Very frequently burnt sites had virtually no woody exotics. Similarly, significantly fewer herbaceous weed species were found in very frequently burnt areas than where fire frequency had been low. There was a significant negative association, at a small scale, between the abundance of *Themeda australis* and the richness and abundance of exotic herb species: more *Themeda*, fewer weeds. Again these results echo those from grasslands and grassy woodlands elsewhere (Lunt and Morgan 1999, Prober *et al.* 2005).

Fuel

We also assessed fuel loads in CPW at different times after fire. Fuel accumulation in CPW starts from a low base as even low intensity fires consume most available fuel. Modeling based on field data indicated equilibrium fuel loads would be reached within ten years. The peak loads of around nine tonnes per hectare are very low relative to those in nearby sandstone woodlands. Eucalypt litter (leaves, sticks and bark) was the major contributor to fuel loads. The contribution of shrubs, mostly Bursaria bushes, was many times higher in infrequently burnt sites than where fire had occurred at least once a decade. These findings have major implications for balancing conservation and property protection; the two aims conflict to a lesser extent in CPW than they do in Sydney's sandstone environments.

Management Implications

Interfire intervals between four and 12 years are predicted to maintain *Themeda* woodland with Bursaria thickets, open areas, and obligate seeder shrubs. Variable intervals across time and space within these thresholds should maintain much of the landscape at fuel levels compatible with property protection. Low fire frequency remnants dominated by Bursaria retain many conservation values, but are likely to support lower abundances of obligate seeder shrubs and open patch herbs, and more weeds, than remnants burnt once or twice a decade. Experimentation with one or two short interfire intervals may be appropriate in long unburnt CPW. Despite perceptions of overburning, very frequently burnt CPW remnants are not common, and those that do exist are not adequately conserved. Although shrub abundance is low, these areas are less weedy than others, have a diverse ground flora, provide habitat for macropods, and contribute to structural diversity across the Plain.

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Conservation management options for native grasslands of northern Victoria

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Lowland areas of northern Victoria were previously covered by extensive open tussock grassland plains. These plains contained diverse flora including many shrubs, sub-shrubs and summer-active species. Agricultural land use of this region has led to reduced dominance of native shrubs and other grazing-sensitive native species. In their place, winter active species (e.g. *Austrodanthonia*), exotic annual grasses and exotic geophytes have proliferated.

Current management of native grasslands on public land in northern Victoria is based on managing the requirements of rare and threatened fauna, with sheep grazing regimes applied to deliver a specific habitat structure preferentially used by these species. For plant species, however, the goal is to maintain diversity, often by focusing on biomass reduction. The use of stock grazing as a management tool to achieve these aims, however, remains poorly understood. Two opposing views are often expressed by managers in relation to the use of grazing as a management tool: 1) stock grazing is a **habitat regime** that maintains habitat structure for Plains Wanderer and species with similar requirements by applying grazing whenever deemed necessary to reduce or create specific structural outcomes; and 2) stock grazing is a **winter grazing regime** which aims to enhance general floral and faunal habitat complexity by increasing long-lived species and grazing-sensitive species, and reducing the dominance of winter active grasses, exotic geophytes and annual weeds.

Habitat Regime

The habitat creation regime aims to create suitable grassland structure for Plains Wanderer and other fauna and flora species with similar requirements through the manipulation of domestic stock grazing. Grazing of grasslands is initiated when areas become 'woolly' or overgrown. This can be at any time of the year, but particularly following rainfall events, which increase structural density. Summer grazing increases soil disturbances that can create favourable microsites for the establishment of exotic annuals and exotic geophytes following autumn rainfall events. Summer grazing can be manipulated to maximise suitable habitat through the movement of artificial watering points. However, this then requires further grazing because of its effects on the establishment of exotic grasses and subsequent changes to the habitat structure which follow. Under this regime, it is believed that continuing or slight alterations to the current stocking rates will maintain the desired habitat structure (Fig. 1, dotted line).

This regime assumes that the maintenance of habitat structure for key faunal species will also benefit other species and assist in the maintenance of other ecosystem processes. This regime is seen as particularly suitable for leased land as it enables the leasee to be handed guidelines for when to initiate grazing and remove grazing when specific structural outcomes have been achieved. From a land management perspective, this is an attractive regime to follow and has been recommended for grazing areas that are of conservation significance for Plains Wanderer. Handbooks for this regime have been developed by Parks and Wildlife in NSW and are currently being developed by Parks Victoria using visual estimates of habitat structure to determine the need for grazing.

Winter Grazing Regime

The winter grazing regime aims to enhance habitat by encouraging the growth of (formerly dominant) long-lived species including many grasses, sub-shrubs and shrubs, whilst ensuring current biological values are maintained or enhanced. Grazing is utilised to manipulate the flora, whilst all efforts are made to reduce the negative effects of domestic stock on the native ecosystem. Flowering and seed production of native forbs may be enhanced by using stock grazing to reduce the competition from winter-active grasses and weeds leading up to the spring flowering period. Reduction in erosion of the biological soil crust associated with domestic stock grazing is achieved through manipulating the timing of grazing to coincide with periods of increased soil crust stability. Biological soil crusts are believed to be at their least susceptible to physical disturbance by ungulates when they contain moisture but are not saturated. Selectivity of desired native palatable species is reduced by setting the stock intensity high enough to avoid 'ungrazed sections' and by grazing when the targeted flora is most palatable and nutritious. This may lead to yearly-average densities of stock being higher than that of the 'habitat regime'.

Grazing when water availability is less likely to influence stock movements, and heat stress is minimal, reduces the incidence of over-grazing, erosion and uneven nutrient dispersal, particularly around water points.

The complexity of habitat structure may also be enhanced through the increase in long-lived species. These species should increase given deferment from grazing throughout most of the year and active re-introduction efforts. These

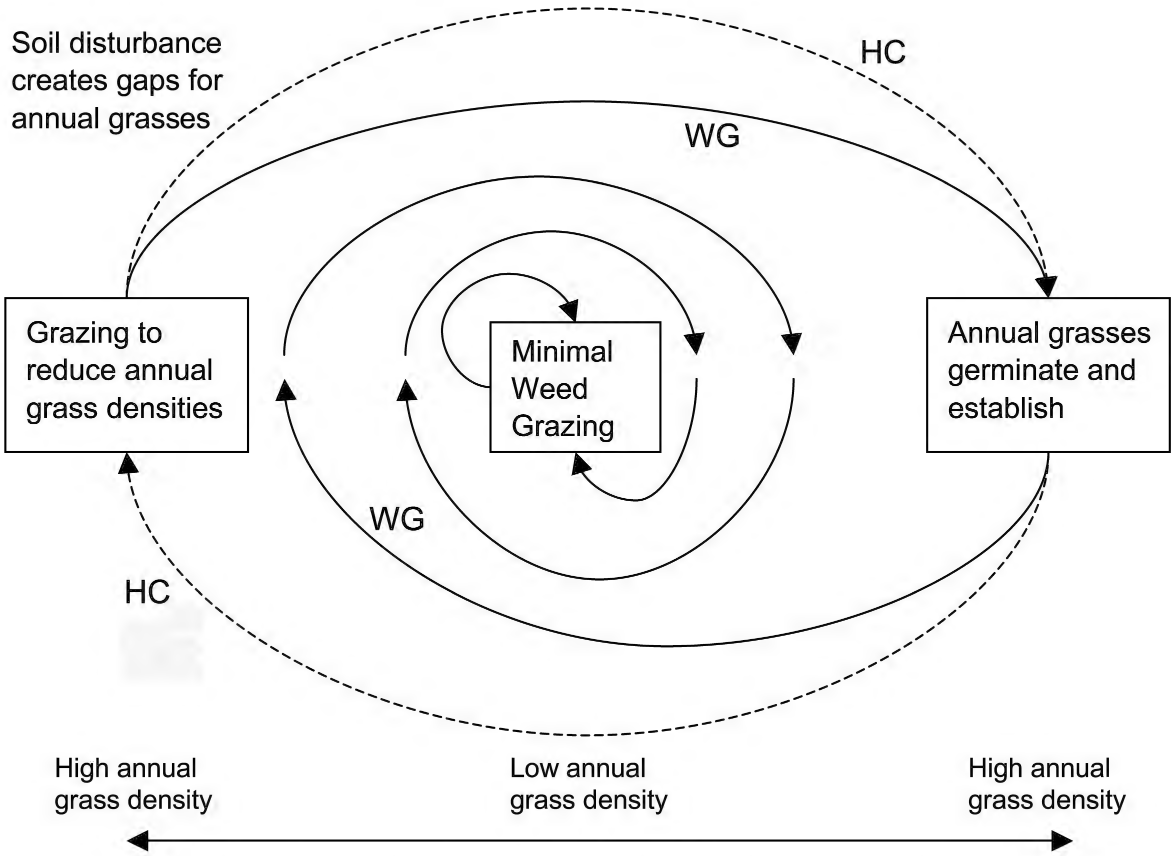

Figure 1. Hypothesised paths followed by alternate management regimes. Centre of diagram is the state with the minimal cover of exotic annual grasses. HC = Habitat creation regime, WG = Winter grazing regime ***Dotted line*** *is the hypothesised outcome of the habitat creation regime,* ***Solid line*** *is the goal of winter grazing regime.*

long-lived components will increase at the expense of the abundant, short-lived, winter-growing species (e.g. *Austrodanthonia* spp. and *Austrostipa* spp.) and weeds.

The use of fire/grazing combinations may have great potential in this system to enable gap creation in the more fertile sections of grassland and may prove useful for restoration efforts. Fire may also stimulate germination of long-lived grasses and shrubs in areas where they have been reduced.

This regime involves deferring most grazing over the Spring/Summer/Autumn period (Fig. 1, solid line).

Fire as a management alternative/complement to grazing

Fire may also be an option to replace or complement grazing as it gives less biased biomass reduction and can be timed for maximum growth and dominance of summer active species. It is a gap creation tool and may reduce densities of annual weeds through reduced soil disturbances associated with domestic stock. The use of fire is hypothesized to shift grasslands to a state where minimal grazing to control weeds is required and grazing can be used to solely maintain habitat structure and complexity whilst minimising soil disturbances (Fig. 1, centre of diagram).

Current Research

We are conducting research on Trust For Nature managed grassland reserves across the Victorian Northern Plains asking questions about whether burning and a winter grazing regime have similar biodiversity outcomes to the more usual habitat regime. The impact of removing stock from reserves will be investigated using long-term exclosures to detect changes. More detailed studies will investigate links between biodiversity, function and grassland structure. The outcomes aim to contribute to the understanding of management impacts on grassland structure and floristic composition. This will allow more sophisticated use of management to create outcomes that are positive for both the flora and fauna of these threatened ecosystems.

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Burning the fringe: managing fire in an outer suburban vegetation remnant

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Introduction

Fire is a conspicuous feature of many Australian ecosystems and it is now used regularly to manage areas of native vegetation. Individual fires cause dramatic shifts in the distribution of biologically important resources and lead to changes in the structure and composition of ecological communities. However, even subtle differences in the timing and intensity of fires can have a major impact on the species that inhabit an area. As a result, every fire adds a unique dimension to the land and contributes to a complex, largely invisible disturbance regime that can vary dramatically over small spatial scales. Sustaining the biodiversity that has evolved with this complexity has become a major challenge for managers of natural areas (Keith *et al.* 2003).

In the last decade land managers have been provided with a number of practical tools to assist with the development of fire management strategies that target biodiversity outcomes. These include the availability of low-cost GIS and database technologies as well as guidelines that help managers to develop hypothetical, ecologically sustainable fire regimes based on the life-histories of organisms living in an area. These guidelines facilitate the creation of fire-diverse landscapes where frequency, timing and intensity of fires can vary within acceptable ranges across an appropriate age-class distribution. The approach creates consistent and explicit targets that can be assessed and reviewed at a local, regional and state level (Fire Ecology Working Group 2004).

Towards a fire landscape

The Royal Botanic Gardens Cranbourne (RBGC) is one of the few relatively large fragments of vegetation remaining in the Greater Melbourne region, Victoria. Although less than 400 hectares in area, the RBGC contains some of the last high quality stands of remnant

Fire is used to construct a diverse patchy landscape. Photo: RBGC

heathy woodland and grassy woodland vegetation in the region. Prior to broad-scale clearing of the land, these communities formed part of an extensive tract of open woodland that spanned the northern sections of the Mornington Peninsula from Port Phillip to Westernport Bay. The remaining isolated patches of vegetation are now crucial to the conservation of biodiversity in the region. However, management of the vegetation is compromised by a number of obvious external considerations.

Although the vegetation communities at the RBGC are adapted to recurring fire, the first deliberate use of fire did not occur until 1993. At that time most of the site had not been burnt for more than 40 years. The burn was undertaken to 'encourage floristic diversity and provide suitable habitat for native mammals', primarily focused on a regionally important population of the southern brown bandicoot. The RBGC bandicoot population had been studied at the site since the early 1970s and was believed to preferentially use certain stages of regrowth after fire (Lee and Cockburn 1985). Planning for the burn included the establishment of permanent vegetation monitoring quadrats and a detailed post-fire monitoring program to assess the long-term outcomes. Subsequent monitoring indicated a dramatic and sustained increase in plant species richness including the presence of species that appeared to have declined in the decades prior to the burn. Ongoing survey of mammals and birds suggested that the regrowth also provided suitable habitat for a diverse fauna community.

Following the success of the 1993 burn, further burns were planned and conducted with the aim of reducing the amount of long-unburnt vegetation. All of the planned burns included pre- and post-burn surveys to assess the impact of fire on vegetation, and monitoring now extends broadly across the site to provide pre-burn data for a number of alternative potential sites. Fires and other disturbances dating back to 1950 have been mapped using GIS to identify over and under represented age-classes to guide the burning program. New fires, planned and unplanned, are added to the picture and feed back into the planning process. As a result of these actions fire diversity at the site increased at close to the desired rate from 1993-2005 and there appear to be ongoing biodiversity benefits.

Conclusion

Management of biodiversity in small patches of vegetation in urban areas presents many challenges and inevitably requires compromise. The location and size of the RBGC limits the size and intensity of individual burns. Planned fires only occur under conditions that restrict fire intensities and this constrains diversity in the timing and intensity of fire in the landscape. Furthermore, planned fires must be limited in the area they affect to maximise the range of fire regimes represented. This has implications for the amount of non-fire disturbance needed to safely conduct ecological burns (eg. fire control lines). Fire can also provide opportunities for exotic plants and animals, many of which pose a major threat to biodiversity in urbanised areas. Despite these restrictions, the approaches outlined here have provided an explicit and transparent direction to fire management at the RBGC and indications are that we have so far achieved our objectives. Ongoing monitoring will hopefully determine whether there is a need to modify the way fire is currently implemented at the site or whether fire is an appropriate management option in the future.

Mass seed germination is a feature of burn sites in the months after a fire. Photo: Terry Coates

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Varying fire regimes to promote fungal diversity across the landscape

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Introduction

Fungi are a major component of the biodiversity of eucalypt forest ecosystems, and are incredibly diverse in respect to species richness and abundance. Fungi play important roles in the decomposition of organic matter, nutrient recycling and nutrient uptake into plants via mycorrhiza formation. Sporocarps of hypogeous truffle-like fungi also form a significant part of the diet of many mammals. In older trees, decay fungi contribute to the development of suitable habitat for many birds and animals. Despite their importance, fungi are often ignored in studies dealing with the impact of forest management on eucalypt forest ecosystems.

In southern Australia, high intensity fire is used as a management tool to aid regeneration of commercial eucalypt forest following clear-cut harvesting, and low intensity prescribed burning is used for community protection and biodiversity conservation (Abbott and Burrows 2003). Most forest fungi inhabit the organic soil layer, litter and woody debris. Fire, by partially sterilising soil, altering the availability of soil nutrients and reducing or totally destroying litter and debris, can have a direct effect on fungi. The influence of these factors is dependent on fire intensity. In Western Australia, recent studies have shown that fire can have a significant impact on the structure and diversity of macrofungal communities and fire has the potential to significantly increase the diversity of fungi across a landscape (Robinson and Bougher 2003, Robinson *et al.* submitted).

Fire regimes and macrofungal diversity

Some fungi respond directly to fire. During a post-fire succession, such species are gradually replaced by species more commonly found on long unburnt sites. Monitoring sporocarp production on burnt and unburnt sites immediately following a wildfire in Karri regrowth forest in Western Australia showed that fungal community structure on burnt sites differed each year following the fire for at least five years. Sixty four species (19% of all species recorded) were associated with the burnt forest (Robinson *et al.* submitted). Of these, 41 were recorded in the first year following the fire, the most abundant being *Neolentinus dactyloides*, *Peziza tenacella*, *Pulvinula archeri* and *Geopyxis carbonaria*. A few of these species, including *P. archeri,* fruited for 2-3 consecutive years, but with decreasing abundance. The change in species composition appears to occur largely within species fruiting on the soil. Concurrently, there is an increase in species associated with the gradual build-up of firstly leaf then twig litter and soil organic material. Therefore, creating a mosaic of fire ages across a landscape has the potential to enhance fungal diversity within that landscape (Fig. 1).

A number of fungi in Karri forest, including *N. dactyloides* (Fig. 2b,c), *Laccocephalum mylittae* and *L. tumulosum* (Fig. 2a), respond immediately to the fire by developing sporocarps from subterranean sclerotia (Robinson 2001). Others germinate from resting spores in the soil and proliferate in the alkaline soil conditions that result following fire. As soil pH drops the alkaline tolerant fungi disappear and species that are more common in long-unburnt forest begin to appear. As the litter, twig and small diameter woody debris builds up recolonisation by saprotrophic fungi occurs from surrounding unburnt forest. Species such as *Mycena* spp. and *Marasmius alveolaris* begin to appear 2-3 years following fire.

In Jarrah forest with contrasting fire histories, fungi species composition also differs, with long-unburnt forest having more mycorrhizal species and

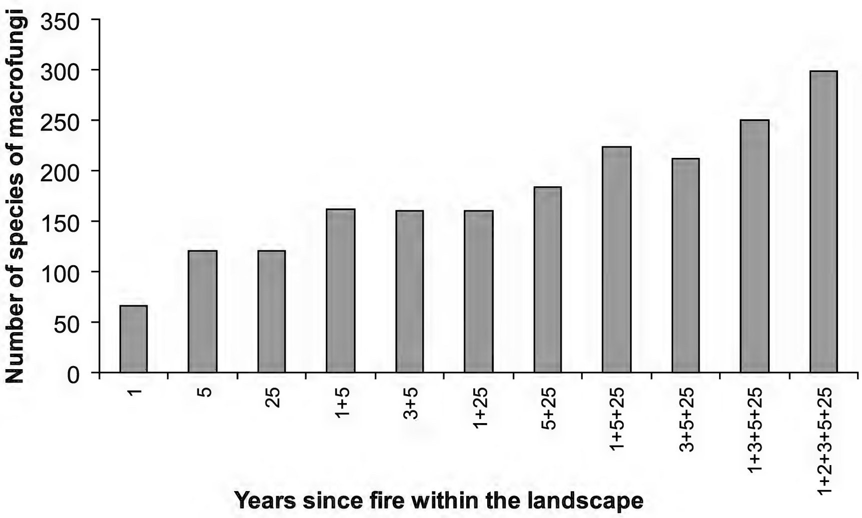

Figure 1. The potential number of macrofungal species that may colonise karri forest following either a single fire event across the landscape or multiple fire events within different patches of the landscape.

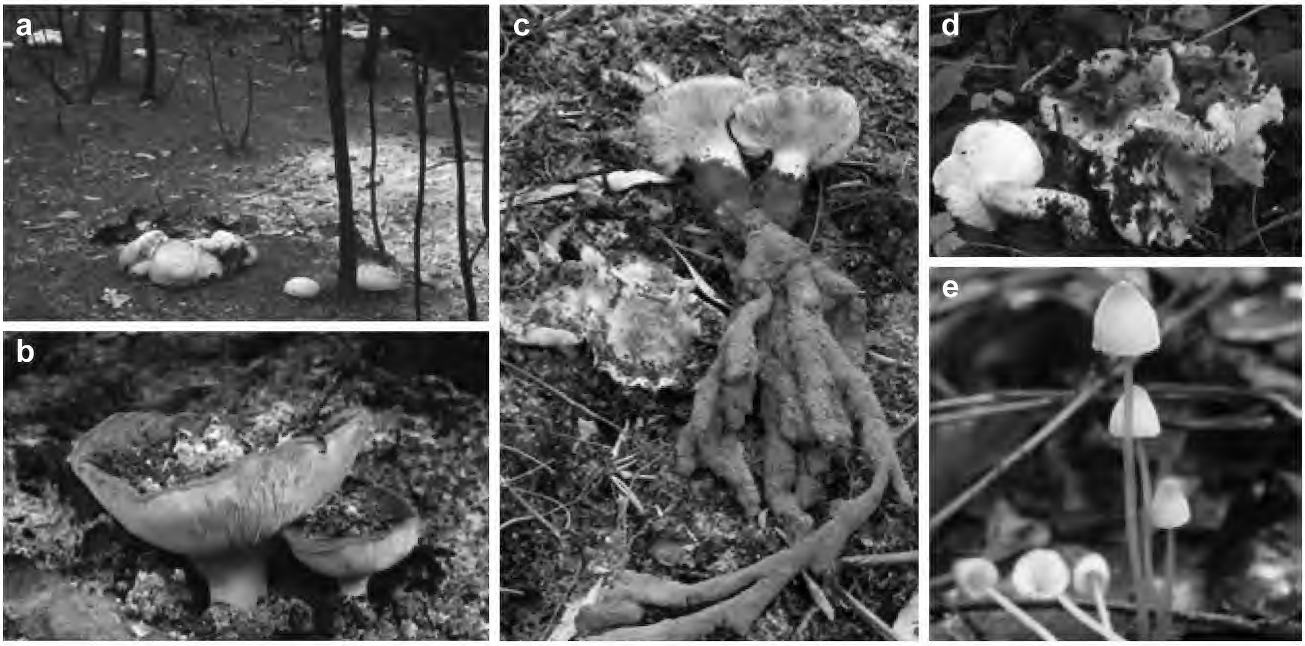

Figure 2. (a) Laccocephalum tumulosum *sporocarps 48 hours following a fire in jarrah forest. (b) Sporocarps of* Neolentinus dactyloides *emerging from an ash bed and (c) the large root-like sclerotium from which the sporocarps develop. (d)* Tricholoma eucalypticum, *a mycorrhizal species, and (e)* Mycena sanguinolenta sensu lato, *a saprotrophic species, occur in both recently burnt and unburnt jarrah and karri forest. Photos: Richard Robinson*

relatively fewer saprotrophic species than regularly burnt forest (Hilton *et al.* 1989, Tommerup *et al.* 2000). Molecular techniques show that more mycorrhizal root tips are present on long-unburnt sites than on regularly burnt sites (Glen *et al.* 1999). However, *Amanita xanthocephala* and *Tricholoma eucalypticum* (Fig. 2d) are two mycorrhizal species that are found in equal abundance in both burnt and unburnt Karri forest (Robinson *et al.* submitted). *Mycena sanguinolenta sensu lato* (Fig. 2e) is a saprotrophic species that is common on burnt ground in both Jarrah and Karri forest but is also found less commonly in unburnt forest (Robinson unpubl.).

Conclusions

For Australian fungi, there is limited knowledge of distribution, ecological requirements and individual functional roles. This lack of knowledge does not allow for the conservation status of fungal communities and individual fungal species to be accurately determined. Fungal biodiversity, however, appears to be large and the maintenance of this diversity is important for the sustainability of the broader forest ecosystem. Those species that are adapted to survive fire or need fire to trigger spore germination or to provide favourable conditions for colonisation, have central ecological roles to play.

In summary:

- a distinct suite of fungal species responds to fire;
- fire adapted species are gradually replaced over time by species more commonly associated with long-unburnt forest;
- no single burning regime or habitat type is favourable to all fungal species. Long-unburnt, frequently burnt and recently burnt situations each provide distinct habitats that are favourable for some fungi and unfavourable for others;
- different burning histories result in fungal communities with similar diversity but different species composition; and
- diversity in fire regime will optimise diversity in fungal community and function.

Managers should thus aim for a mosaic of fire ages and intensities within forest stands and across larger regions in order to maximise or maintain fungal diversity.

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Can the Port Jackson Fig tolerate fire?

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Ficus rubiginosa (Port Jackson Fig, Rusty Fig) occurs from Queensland south to the Far South Coast of New South Wales, where it is relatively uncommon but widespread, generally restricted to Dry Rainforest or Littoral Rainforest, in gorges, on rocky outcrops, boulder berms, and coastal and inland cliffs. This apparent restriction to fire-protected sites suggests that it is not well adapted to contend with fire.

Port Jackson Fig in Grassy Woodlands

Occasional large specimens of Port Jackson Fig can occur within coastal remnants of the Endangered Ecological Community, Bega Dry Grass Forest, part of the Coastal Valley Grassy Woodlands vegetation class which is dependent on fire for the maintenance of essential dynamic processes (Keith 2004). These figs often occupy sites without topographical fire protection.

Isolated Port Jackson Fig in Grassy woodland on the coast, in a non-fire protected location. Photo: Jackie Miles

In August 2004 a wildfire burnt through a dense Grassy Woodland remnant south of Bermagui, on the far south coast of NSW. Three clumps of *Ficus rubiginosa* were affected by the very intense fire. While two clumps were scorched on the north side only, the largest, a clump 28 m across and 8 m tall, was more seriously damaged. The fire swept around it and through most of the dense groundcover, scorching 75% of the canopy but leaving an unscorched 'island' to the south-west. The 'sacrificed' non-combustible foliage had sheltered a portion of the fig from the fire and within its canopy several other species. Dead limbs had caught fire and burnt back to living tissue, which is not readily combustible.

Five months after the fire smaller branches on the north side of all three figs were dead as was the bark on the lower side of larger branches. A vigorous and dense regrowth of shoots was evident, predominantly on the upper side of larger branches and also from points where branches contact the ground and presumably have rooted. Multiple shoots commonly arise from each epicormic node. The general effect is very similar to the resprouting of fire-affected eucalypts. By February 2006, 17 months after the fire, the canopy was fully restored on two of the figs and to about 80% on the most fire affected.

Port Jackson Fig showing a fire scar, presumably from a 1952 wildfire. Photo: Jackie Miles

That *Ficus rubiginosa* can eventually make a full recovery from fire is evidenced by a large specimen growing nearby but unaffected by the fire discussed here. There is now no evidence of past fire damage to this fig but an old *Eucalyptus* stag well within the canopy is charred up to 3 m and a living *Eucalyptus tereticornis* on the edge of the fig canopy bears a 1 m tall fire scar at the base.

Conclusions

These observations suggest that, once well established, individuals can survive without topographical fire protection, and to some extent themselves constitute protected sites due to the fire-blanket effect of their non-combustible foliage, their combustion-resistant wood, and (generally) the suppression of vegetation beneath their canopy.

That *Ficus rubiginosa* can tolerate scorching by fire and does not appear to suffer significant long-term damage, accounts for the occurrence of the species within tracts of Grassy Woodland.

Management of fire, grassy woodlands and figs

Fire will generally be integral to management of Grassy Woodland remnants. Managers need not be unduly concerned that apparently fire-sensitive figs, with a keystone role in the ecosystem, will be destroyed by fire. However a fire regime of frequent cool fires, which suppress the dense shrub growth which fueled the fire described here, is still less likely to damage the figs. It is desirable to exclude fire from the more vulnerable younger generation of figs establishing on stumps, in crevices and as epiphytes.

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Rehabilitation of Mountain Beech (*Nothofagus solandri* var. *cliffortioides*) forest after fire

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Introduction

Forests dominated by Beech (*Nothofagus*) species cover about 3 million hectares and account for almost half of the total area of indigenous forest in New Zealand. Forest fires occur relatively frequently in Beech forest in drought prone eastern areas of the South Island. New Zealand beech species are poorly adapted to fire (Wardle, 1984) and even low temperature burns can lead to forest destruction. Forest areas destroyed by fire, particularly in drier eastern regions, can be very slow to regenerate as seed is infrequently produced and is not adapted for long distance dispersal (Allen and Platt, 1990; Wizer *et al.* 1997). Hence, forest regeneration characteristically occurs by slow marginal spread, and away from margins. Regeneration following fires often results in a new vegetative cover of scrub or grassland, dominated by exotic species. If land managers wish to accelerate the recovery of native forest after fire, active rehabilitation may be required. The opportunity to test whether Beech might be rehabilitated by seeding after fire came in the early 1980s at Mt Thomas forest in north Canterbury, when a fire from adjacent farmland got out of control and burnt approximately 300 hectares of Mountain Beech (*Nothofagus solandri* var. *cliffortioides*) forest (Ledgard and Davis 2004).

The trial

A mixture of Mountain Beech, the pioneer shrub Manuka (*Leptospermum scoparium*) and other small native tree and shrub species were sown within a year of the fire in the presence and absence of introduced pasture species as a cover crop, and fertiliser. The trial area was fenced from large browsing animals (e.g. Wild Deer and Pigs), but not from smaller mammals, such as Possums and Hares.

Results

Seeding of Mountain Beech and Manuka was successful, but limited success was achieved with the other native woody species. Competition from the pasture species, Browntop (*Agrostis capillaris*), Cocksfoot (*Holcus lanatus*) and White Clover (*Holcus lanatus*), inhibited establishment of all native species. Fertilisers, in the form of molybdenised superphosphate and diammonium phosphate at the rate of 1000 kg and 80 kg/ha respectively, increased Manuka plant numbers in the first year but had no other beneficial effect on establishment of native species. Manuka provided a dense shrub cover in plots where the native species were sown in the absence of pasture species, but Mountain Beech had begun to overtop the shrub canopy, 20 years after seeding. Browsing by insects or small animals (Possums and Hares) in the first two years was the main cause of mortality in Mountain Beech.

Discussion

Mountain Beech was sown within a year of the burn, and the extent to which its establishment might have been successful if seeding was undertaken after a longer time interval is unknown. However, the fast rate of development of competitive herbaceous species would be an important factor in determining the success of a later seeding. In plots where native woody species were sown, cover of native woody species, including that from natural regeneration, after nearly four years, was <1% where pasture species were sown, compared to about 30% where pasture species were not sown. The influence of pasture species was still evident after nearly 20 years, when the cover of native woody species had risen to 25% and 83% in the presence and absence of sown pasture species respectively.

The study has shown that the slow return to Mountain Beech forest dominance after fire can be accelerated by sowing seed shortly after the fire event. The window available for achieving good establishment of Mountain Beech and other woody species may be no more than 2 years. This may create difficulties in many instances as Mountain Beech, in common with other beeches, produces seed infrequently (Wardle, 1984). Although the trials did not determine whether the presence of Manuka as a 'nurse' crop assisted Mountain Beech establishment and growth, in terms of producing a dense cover of native woody species as quickly as possible, the seeding of a combination of Manuka and beech appears particularly effective. Where Mountain Beech seed is not immediately available, seeding of Manuka by itself may be useful to allow subsequent introduction of beech seed, since Mountain Beech appears to establish preferentially in Manuka stands.

The seeding rate for Mountain Beech was about 1.0 kg/ha. This rate produced stockings of around 1800 saplings/ha after nearly 20 years. While such a stocking would be highly acceptable for rehabilitation, obtaining the quantities of seed required for an area the size of the Mt. Thomas burn would be difficult. An alternative for large areas could be to 'spot-seed', with the aim of establishing a low density of seed trees. Once these matured, they would provide the seed needed to establish a new forest from marginal spread. At Mt Thomas, sowing 2-3 g of seed at spots 20 m apart (25 spots/ha) would have resulted in the establishment of about 50 trees/ha after 20 years. Using this approach, about 20 kg of seed would have been required to cover the whole of the burnt area. The seeding rate used for Manuka (6.0 kg/ha) was excessive, producing about 15 plants/m^2 at 3.5 years, and could be reduced substantially. Research is required to determine any nurse crop role for Manuka, and its optimum densities for subsequent establishment of the Mountain Beech.

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Ecological burning for recovery of the threatened Spiny Rice-flower

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Introduction

Spiny Rice-flower (*Pimelea spinescens* subsp. *spinescens*) is a small shrub endemic to the state of Victoria. Its key features are the spine-tipped stems and branches and small creamy yellow flowers that appear in the winter months of June, July and August.

Spiny Rice-flower is found in the grasslands of the Northern Plains between Mitiamo and Echuca and on the Basalt Plains from just west of Melbourne to as far west as Lismore. It was previously thought to be exclusively found in these grassland areas until populations were recently discovered in grassy woodland communities near Stawell, Bendigo and Axedale.

The species has been listed as 'Endangered' under the *Victorian Flora and Fauna Guarantee Act 1988* and 'Critically Endangered' under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.* This has led to the development and implementation of a Recovery Plan which identifies the research and recovery actions needed to protect and conserve the species. One of the key actions specified is to implement ecological burning in a number of Spiny Rice-flower populations.

Why Burn?

Due to large-scale clearing across the state for agriculture, the vast majority of known Spiny Rice-flower populations occur on roadsides or rail reserves. These forms of land tenure have little security and many management issues, with weed invasion the most common problem they share. Due to Spiny Rice-flower being a stunted and sometimes semi-prostrate shrub, it is susceptible to being out-competed by exotic plant species.

Aggressive perennial invaders such as Phalaris (*Phalaris aquatica*) and Tall Wheat Grass (*Lophopyrum ponticum*) are often the main problem weeds. To a lesser extent, annuals such as Wild Oats (*Avena* sp.) and Quaking Grass (*Briza maxima*), and deciduous geophytes such as Onion Grass (*Romulea rosea*) are competing with all native species on these sites, not just those that are threatened such as Spiny

Top: Spiny Rice-flower habitat within a rail reserve before burning; note the weed density adjacent to the rail line (also visible in other photographs).
Middle: Same habitat immediately after burning.
Bottom: Same habitat the following spring.
Photos: Ben Thomas

Rice-flower. These exotic species can threaten the longevity of a Spiny Rice-flower population in two ways: firstly, by filling the inter-tussock spaces needed for germination and recruitment of seedlings, and secondly, by out-competing the existing mature Spiny Rice-flower plants for light and soil nutrients. Interestingly, those plants in competition with weeds begin to take on the same form as plants found in grassy woodlands – more prostrate and spindly.

Exotic species are not the only threat to Spiny Rice-flower. At most sites where it is found west of Melbourne, Kangaroo Grass (*Themeda triandra*) is often a dominant feature of the grassland habitat. However, left unmanaged, this grass will close-in the inter-tussock spaces that forbs and sub-shrubs, such as Spiny Rice-flower, require to grow and reproduce. Fire and grazing can be used as management tools to reduce this biomass, create open spaces and thus maintain site biodiversity.

Fire can be a cost- and time-effective management alternative to stock grazing. It is quick, non-selective and only needed every 3-5 years depending on other factors such as rainfall or the return of exotics post burn. (Ideally, after the first rain break post-burn, fresh green growth of any weeds that may arise should be spot-sprayed to help prevent a resurgence of weed cover).

Ecological burning is a relatively new management tool used specifically for the recovery of Spiny Rice-flower, but is an old management tool for the management of rail and road reserves. Rail reserves in particular were often burnt annually as a way to reduce the risk of fires being ignited by passing locomotives. Many road reserves on the other hand have historically been burnt every couple of years by local CFA brigades to act as strategic firebreaks. Some of the best grasslands in the state are found alongside used and disused rail lines and road reserves. Historical fuel reduction burning is now being replaced with ecological burning as a way of maintaining the *status quo* of biodiversity values.

Ecological burns

Local CFA brigades have conducted ecological burns on behalf of Department of Sustainability and Environment (DSE) biodiversity staff who manage and implement the Spiny Rice-flower Recovery Plan. Usually quite small areas are burnt, and provide a good training opportunity for CFA members.

Timing

All ecological burns for Spiny Rice-flower that have been conducted so far have generally been between late summer and mid-autumn. Spring burns have not yet been tested. An autumn burn usually results in Spiny Rice-flower missing out on a flowering season, however for the long-term health of the species and the grassland habitat in general, this is a small setback. For grasslands, autumn burns are generally considered the best option (as opposed to a spring burn) because most other grassland plants will get the opportunity to flower and drop their seed, whilst in spring they are only just starting to flower.

Results

At many burn sites a 10x10 m monitoring quadrat has been established. The sites are/will be surveyed before and after each burn (at least 12 months or more), using the Braun Blanquet method. As most sites have only been burnt one to two years since monitoring was established, there is insufficient data for detailed analysis.

However initial observations and anecdotal evidence suggest that the sites recover well and that weed cover is reduced dramatically. Spiny Rice-flower itself recovers quickly, even after the woody stems of the plant are burnt to ashes above the ground. Re-sprouts can be seen as quickly as two months after the fire event, and in less than 12 months a bushy and healthy looking plant has replaced an old and spindly one. The source of this quick recovery is a deep taproot that can extend to well over a metre in depth.

Conclusion

Ecological burning is a cost-effective method of controlling plant biomass and weed cover where grazing is not appropriate. An ecological burn appears to improve the health of Spiny Rice-flower and its habitat. Although established ecological burning for the species has been used only at a small number of sites across Victoria, their success had led to plans to conduct such burns at other sites on the Basalt Plains, where many Spiny Rice-flower sites have been historically burnt for other purposes, and on the Northern Plains, where sites have historically been subject to grazing.

The use of local CFA brigades to do ecological burns provides an opportunity for community involvement, a key part of threatened species recovery, and another opportunity to educate the community about rare and threatened flora in their area.

Acknowledgments

Thanks to Andrew Arnold, Cath Grant, Deanna Marshall, Jenni Thomas, and Neville Walsh for contributions to this article.

Observations of fire response for the rare plant *Haloragis exalata*

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Raspwort, *Haloragis exalata* (Haloragaceae) is a rare perennial forb restricted to scattered locations on the east coast of Australia. Plants do not form a permanent woody stem, but produce masses of stems from the base and typically occur in damp places near watercourses. This paper describes observations of the response to fire of a recently discovered population of *H. exalata* subsp. *exalata* var. *exalata* at Geehi Dam within Kosciuszko National Park following the 2003 Kosciusko fires.

Taxonomy and status of *Haloragis exalata*

Haloragis exalata is divided into two subspecies, subsp. *exalata* and subsp. *velutina*, the latter occurring only in northern NSW and Queensland. *Haloragis exalata* subsp. *exalata* is further subdivided into var. *exalata* and var. *laevis*, the latter distinguished by having glabrous stems and leaves and is apparently restricted to the Central Coast botanical division of NSW. Whereas, *H. exalata* subsp. *exalata* var. *exalata* has scabrous stems and leaves and has been recorded from the Hunter Valley, the Sydney region, a few locations on the NSW South Coast, one location at Geehi on the Southern Tablelands and two areas in south-western Victoria. The recently discovered Geehi population displays certain morphological features which may result in its eventual separation as a distinct subspecies. Pending possible taxonomic revision it has been determined as *Haloragis exalata* subsp. *exalata* var. *exalata.*

Because of the very small number of modern records (prior to 2001) *H. exalata* subsp. *exalata* is listed as vulnerable under the NSW *Threatened Species Conservation Act 1995* and nationally under the *Environment Protection and Biodiversity Conservation Act 1999*.

Discovery of a new population

Haloragis exalata subsp. *exalata* was first discovered at Geehi in 2002 when three small patches were discovered on road verges and a power line easement during environmental impact assessment surveys conducted at Geehi Dam in Kosciuszko National Park. Geehi Dam is a large impoundment on the Geehi River, constructed in the 1960s and used for hydroelectricity generation. The Dam is located in extremely steep ranges 3-4 kilometres west of the Kosciuszko Main Range, at an elevation of 1100 metres.

Response to the 2003 fires

The January 2003 Kosciuszko fires burnt some of the forest in the vicinity of Geehi Dam and a survey of the response of *H. exalata* to the fires was commissioned by the NSW Department of Environment and Conservation (then NSW National Parks and Wildlife Service). This survey was conducted in December 2003, some 10 months after the fires.

The continued presence of *H. exalata* in the areas where it had previously been recorded was confirmed and additional records were made from previously unsurveyed sections of road verges and batters. The survey did not provide information as to whether adult plants are capable of resprouting after fire, since all plants previously recorded

Fruiting Haloragis exalata *from Geehi Dam. Photo: Jackie Miles*

had been in protected sites on road verges which had not burnt. In areas where the adjacent forest had burnt, seedlings of *H. exalata* occurred both on the road batters and extending into the forest, where they were often extremely numerous. Population numbers at the time of the survey were estimated to be in the thousands, if not tens of thousands, with up to 90% of plants being seedlings. Some plants were producing flower buds while still quite small (<30 cm).

A third survey of the Geehi Dam area was made in June 2005, approximately 2.5 years following the fire. The majority of plants had fruited and the tall flowering stems were dying back, to be replaced by new shoots arising from the base. The volume of seed production appeared to have been very high, though some plants in shadier sites had flowered less profusely.

The 2005 survey also extended the known occurrences of *H. exalata* up to about 14 km from the dam wall. It established that the plants extend for more than 50m above roads and tracks in burnt forest as well as occurring on road cuttings. In some locations *H. exalata* was one of the dominant species in the regenerating understorey. This was particularly the case on a burnt power line easement, where a tree canopy was lacking. *Haloragis exalata* was found to be present both in areas which had burnt at high intensity (indicated by death of the alpine ash, *Eucalyptus delegatensis*, canopy) and areas where the understorey had been consumed with no canopy scorch. On the basis of limited observations in two areas, it appeared to be more abundant in the lightly burnt area, which had a more grassy understorey, compared with the high fire intensity site, where there was a very dense regeneration of tree and shrub seedlings (mostly *E. delegatensis* and *Daviesia latifolia*). However it is not clear whether this difference relates directly to the fire intensity, to differences in the understorey prior to the fire, or to the differing density of the post-fire regeneration. *Haloragis exalata* was also uncommon where there was a dense groundcover of the fern *Polystichum proliferum*. It appeared most common in areas where there was still a relatively large proportion of bare ground.

Comparison with coastal populations

Through 2001-06 the authors have also observed *H. exalata* subsp. *exalata* at a large proportion of the other sites where it has been recorded. Populations are largely confined to sites where some form of recurrent disturbance temporarily suppresses groundcover vegetation, bares the ground and, in many cases, results in a degree of canopy breakdown and an increase in light intensity at ground level.

The disturbance mechanisms in coastal populations include erosion and deposition by floodwaters, prolonged inundation by saline water, baring of soil by track construction or animal excavations and collapse of senescent canopy trees. At Geehi, although disturbance by road construction and animal digging appears to promote small scale germination, the most important agent is fire, the major fire of January 2003 having established conditions for the germination of a very large population extending discontinuously over at least 14 kilometres. The size and density of this population imply considerable longevity for seeds stored in the seed bank. While fires of the intensity and extent of that of January 2003 are likely to be uncommon, fires have been recorded in the vicinity of Geehi Dam in the 1972-3 summer and in 1993 (Craig Smith, DEC Ranger, Geehi/ Jagungal, pers. comm.). Our observations suggest that in the absence of fire a small above-ground population would persist in such disturbed sites as track verges, landslips and where soil is disturbed by wombat excavations.

Management of the Geehi population

The key to conservation of this rare taxon, and specifically the disjunct and possibly genetically discrete Geehi population, is maintenance of an appropriate disturbance regime. Observations suggest an appropriate disturbance regime would include occasional major fires and more frequent small scale disturbances such as landslips and where soil is disturbed by wombat excavations. It is unlikely that too frequent fire would be an issue in the management of this species, since the habitat at Geehi is wet sclerophyll forest, in which conditions are unlikely to be suitable for fire except in major droughts. For maintenance of small residual populations between fire events some deliberate management actions may be needed. For example timing of road works needs to be scheduled to take account of the plant's seeding time and any control of roadside weeds must be undertaken with considerable care.

Fire, forest health and biodiversity

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Evolution

Our unique flora and fauna evolved as Australia became more arid, infertile and fire prone as a result of continental drift, climate change and erosion. Thus fire is overwhelmingly important in maintaining our ecosystems (Attiwill 1994). Frequent mild fires ignited by lightning and Aboriginal people stabilised our ecosystems and kept them healthy (Jurskis 2005a). Low intensity fire was no more a disturbance than rainfall in a Blue Gum forest, snowfall in an Alpine Ash forest or flood in a River Red Gum forest. The ecosystems that evolved in this environment do not fit traditional ecological concepts of disturbance, natural succession, enrichment and climax communities (Attiwill 1994).

Disturbance changes the composition, structure and function of an ecosystem. In traditional ecology disturbance restarts a succession where pioneer and then secondary species gradually enrich the environment and eventually give way to stable climax communities. Some Australian ecologists ignore the evolution of Australian life and consequently do not distinguish between the mild and patchy fire regimes that shaped our ecosystems and the severe fire regimes that are a result of our current management. They view fire as an ecological disturbance, and fail to recognise exclusion of fire as a severe disturbance to our fire-dependent ecosystems. Consequently there is a theory that frequent prescribed burning will make some species extinct. However studies of frequent prescribed burning do not support the theory (e.g. Jurskis *et al.* 2003).

European settlement

Fire regimes changed after Aboriginal people were displaced and settlers suppressed fires. In the early 20th Century, forest managers tried to suppress fires on a much broader scale. Consequently, disastrous fires occurred across Australia, and forest managers adapted by introducing broadscale prescribed burning and aerial ignition. Later, as demographies and philosophies changed, prescribed burning became increasingly unpopular. Burning programs were reduced and disastrous fires are again common.

The natural regime of mild fires across the landscape, and few severe fires has been displaced by a regime of limited burning and extensive severe fires. These are causing extreme soil erosion and siltation, and placing many threatened species on the brink of extinction (e.g. Good 1981, Mitchell 2005). Meanwhile exclusion of fire from fire-dependent ecosystems is having a more insidious impact on ecological processes and biodiversity. The Fire Ecology Working Group (2002) examined current fire regimes in Victoria and concluded that exclusion of fire poses the main threat to biodiversity. Declining health of trees, scrub invasion and proliferating pests and weeds (including natives) are consequences of current fire regimes in much of Australia.

Clockwise from top: Current fire regimes across much of Australia are causing decline in the health of a range of ecosystems, including Tuart woodlands in WA, Peppermint woodlands in Tas and Stringybark forests in NSW. Photos: Vic Jurskis.

Fire's ecological function

Fire studies have revealed how frequent mild fires keep can keep eucalypt ecosystems healthy (Jurskis 2005b) (the studies include fire intervals ranging between 1 and 4 years). Fires prevent unnatural accumulation of moisture and nutrients and keep understoreys open and sunny. Without fire, soils become enriched as leaf 'mulch' builds up, nitrogen from the atmosphere is 'fixed' by living organisms, and understoreys thicken and shade the ground. These changes inhibit mycorrhizae that normally enhance tree roots, favour pathogens that attack them, and favour many understorey plants that compete with the trees. The trees' sap and leaves become more nutritious, palatable and accessible to pests, parasites and pathogens. People think that the pests are the problem, however they are only exacerbating the problems caused by our disruption of fire's ecological role. Severe fires reinforce the problem by damaging the trees and stimulating mass germination of competing shrubs, especially nitrogen-fixers that thrive in the ashbed.

Contrasting fire regimes on either side of track, NSW. Photo: Vic Jurskis

Biodiversity or biomass?

The 'European' view of ecology sees the proliferation of dark green shrubbery and 'mulch' as a 'natural succession'. Wildlife ecologists extol the benefits of structural complexity for fauna. Increasing populations of some species, such as koalas, possums and mistletoes, that thrive on declining trees are not recognised as signs of imbalance until tree decline becomes very severe. Meanwhile many less conspicuous plants and animals can be declining. It is impossible to measure total biodiversity, so assessment of the changes will depend on what species are chosen.

In assessing conservation of biodiversity, priority is given to ecosystems that were mostly cleared. These are the open, grassy eucalypt systems that were sought by early settlers for their grazing value. They were frequently burnt before settlement, and are particularly prone to tree decline and shrub invasion when fire is excluded. Ironically many remnants of these ecosystems were maintained in a healthy open condition by grazing (which can substitute for the natural role of mild fires), but have been declining and shrubbing up since they were 'protected' in reserves (Jurskis 2005b).

As grassy, sunny forests with a diversity of herbs, and many rare or uncommon species (e.g. Gaping Leek Orchid, Hastings River Mouse, various ants) change into shrubby and shady, damp forests with dense populations of common and widespread plants and animals (e.g. Sheoaks, Bushrats, Brown Antechinus, cockroaches and other litter dwellers) we are losing biodiversity and gaining biomass (e.g. Tasker and Dickman 2004, Coates *et al.* 2005). These changes also favour exotic weeds such as Lantana, Privet and Blackberry.

Conclusion

We need to restore frequent mild fires into the landscape, particularly where grazing has been withdrawn from conservation reserves, where remnant eucalypt ecosystems are declining and where rare species are threatened by exclusion of fire. Reintroducing a mild fire regime will help to protect the truly fire-sensitive species that live in swamps, rock outcrops, and shady gullies because mild fires cannot penetrate their habitats. In contrast, the disastrous fires that inevitably follow long term exclusion of fire can incinerate all the 'fire refuges' across thousands of hectares (Burrows 2005).

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Fire in the natural environment

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Introduction

Fire is a widely used land management tool. In Western Australia, it is often called 'prescribed burning'. This has various objectives, such as getting rid of logging debris, regenerating specific plants, and reducing the amount of flammable vegetation to make wildfires less intense and easier to control. It is this last category of prescribed burning, also called 'fuel reduction' or 'hazard reduction' burning that is the most controversial. If conducted too frequently, 'fuel reduction' burning can actually increase the amount of flammable vegetation and make the environment more fire prone. Furthermore, in Western Australia, prescribed burn planning does not adequately take into account the recovery times of taxa, communities and ecosystems, for both flora and fauna.

Fire and flora

While some plants can recover quickly after being burnt, others need a long time to recover. For plants that can only reproduce from seed, a reasonable interval between fires is the time it takes the plant to grow and produce its seed, multiplied by two and a half. Some plants take 15 years before they even set seed. They would require fire-free periods of at least 35 years.

Young or new growth on some plants may be fire sensitive for many years. Karri trees need 15 to 25 years before they can survive fire. If a fire occurs again before particular plant species have recovered from a previous fire, those species may eventually disappear from the ecosystem. Certain ecosystems such as peatland – areas that are very moist and contain a lot of organic matter – may never recover from burning. Furthermore, if fires occur too often, nutrients can be lost from the environment and not replaced from humus and decaying vegetation, so the health of the ecosystem will suffer.

Lake Surprise, south-west Western Australia. Repeated fires over the last two decades, including prescribed burns and wildfires, have severely eroded peatlands. Photo: John Austin/jbaphoto, Quinninup WA

Fire and fauna

The immediate impact of fire on all animals is disastrous. Fire kills them unless they are able to escape by moving faster than the fire-front (e.g. kangaroos) or by having deep burrows (e.g. some trapdoor spiders). The ability of animals to recover from fire depends firstly on the recovery of food sources and habitat and secondly on the presence of populations from which the burnt area can be recolonised. In the case of some rats and mice, recovery may occur within two years after a fire, but for Honey Possums it may be 30 years before their populations fully recover.

Burning in spring, when a lot of prescribed burning is carried out, is bad for most birds. This is when they are raising their young, and fire reduces the amount of insects and nectar on which they feed as well as destroying their habitat.

While some animals are present in larger numbers in recently burnt bush, no animal depends on fire for its survival. The example often used of a 'fire-dependent' species is the Tammar Wallaby, which requires dense thickets of vegetation for food and shelter from foxes. Such thickets need a fire-free interval of 25 to 30 years and can be rejuvenated by fire, but this does not mean that the Tammar needs fire for its survival. There is no evidence that the population of Tammars on Garden Island in Western Australia has decreased even though there hasn't been a fire on the island for nearly 50 years.

Indigenous burning

It is sometimes said that we should burn the way Aboriginal people did. Even if we wanted to, it can't be done. Firstly, in most parts of Australia, we don't know how Aboriginal people used fire. Secondly, since European occupation, ecosystems have been changed so much that Aboriginal burning would no longer

Burning peat at edge of Lake Surprise. Organic matter accumulated over thousands of years can be destroyed in a single fire. Photo: John Austin/jbaphoto, Quinninup WA

be possible. Much of the native vegetation has been removed and what is left is fragmented, and buildings, crops and stock that need protection from fire are scattered through it. Logging has left large amounts of debris in the forests and opened them up to more sun and rain and thus more plant growth in the understorey. Also, the native animals like Tammars and Woylies that ate and buried plant material have largely disappeared, so there is a lot more flammable vegetation in the bush now than there was before Europeans arrived.

It has been claimed that in Western Australia the Noongar people burnt the Jarrah forest every three to five years. This claim is strongly disputed and the evidence disproves it. If the Noongars had burnt the Jarrah forest every three to five years, all the plants and animals that need much longer between fires to survive would have disappeared.

A new approach to burning

By reducing the amount of flammable vegetation (the 'fuel load'), prescribed burning may reduce the intensity of wildfires and make them easier to control, but it will not prevent them. Furthermore, controlling wildfires depends on many factors other than the fuel load, such as wind speed and direction, temperature, rain, and the response time, skill and equipment of fire-fighters.

Ironically, prescribed burning as currently practised tends to make the whole environment more fire prone by promoting fire-loving plants and removing natural fire barriers such as peatlands, which are dried out and made more flammable. Instead of relying heavily on prescribed burning, there are many things that we should do to protect ourselves and the places and things we value from wildfires:

- we should plan towns so that we don't build homes in places where there is a high risk of wildfires. If people insist on building in such places, they must be warned of the danger and encouraged to design fire-resistant houses and use fire-resistant materials. Their insurance premiums should reflect the higher risk;
- we need to carry out proper risk assessment and risk management. Wildfire mitigation should focus on areas with a high likelihood of catching fire where the consequences would be most serious;
- since we already have a lot of homes in high fire-risk areas, we need to develop a system of zones for classifying fuel management areas, with clear objectives for each zone. These should be applied across the landscape, and all land managers and the community should be involved; and
- we need to educate the community about wildfires so that everyone knows how to protect themselves, their homes and their environment from wildfires.

If we do all these things, we can protect people, property and biodiversity from unwanted fires.

Redlands IndigiScapes Centre – a Regional Botanic Garden

Rosalie Eustace

Service Manager Environmental Education, Redland Shire Council, QLD. Email: indigiscapes@redland.qld.gov.au

I read with interest the article in the Sep-Nov 05 issue 'Live local ... plant local'. Redland Shire Council developed a regional botanic garden in 2000 called the Redlands IndigiScapes Centre (indigenous plant landscapes) to promote 'local plants in local gardens for local wildlife'. Redland Shire is located south east of Brisbane between the city and Gold Coast.

The key attraction of the centre is the suburban style backyards complete with picket fences and full of landscaping ideas – all with Redlands native flora. There are 14 display gardens including coastal, wild herb, formal, scribbly gum, grey gum, wildlife attracting, creekside, wetland, rainforest and waterwise gardens; two recycle/reuse gardens; an 'over the fence' garden and a hedge maze. The Centre has an information centre, community nursery, café and function room. The Centre is set in 14.5 ha, two thirds of which is natural bushland providing disabled friendly bushwalks.

The intended experience is for residents to be able to walk through the natural bush area at the centre and then come back to the landscape gardens to see how to grow the plants in their own gardens. They can then purchase plants and find out further information at the information centre. A booklet called 'Walkabout IndigiScapes' has been developed to provide visitors with garden plans and plant information.

The original plan was to construct an arboretum or plant collection but the need to change behaviour inspired the construction of sample gardens to show visitors how it's done. The positive response we have had back from visitors is overwhelming and the approach has resulted in the centre being an agent of change in the Shire and beyond. A common response we receive is that this is a lovely place to be, but residents are also excited that the plants they purchase here grow so well.

When designing the gardens, features were included to ensure the gardens were attractive to a wide range of people. The Tea Garden Café attracts a wide diversity of people who love to dine in the natural setting but usually also go for a walk, pick up brochures, look at the displays and often purchase plants and environmental books. A playground and free barbecues and picnic areas make this an attractive venue for families. The function room and gardens are booked frequently for business meetings, weddings and other functions giving staff the opportunity to interest a wide range of people in the value of planting local plants.

Left: Using native plants in a traditional formal garden.
Right: This interesting hedge maze is constructed from local native plants and forms part of the children's play area.
Photos: Jeanette Adams

The Redlands IndigiScapes Centre is also home to a number of community programs including seed bank and seed collection, community nursery, Land for Wildlife, Rural Support Program, Your Backyard Gardening Program, Redlands Wildlife Care Network, Redlands Afterhours Wildlife Ambulance, Schools Program, Community Bushcare and Community Planting Program.

The emphasis is on education and community involvement and many volunteers have been, and continue to be, involved in the development and running of the centre. One of the most successful aspects of the centre has been the propagation and sale of local native plants with demand increasing yearly. One of the challenges for the future will be to continue to bring more of the local indigenous plants into cultivation, especially those that are proving difficult to grow, such as the wedding bush, *Ricinocarpos pinifolius* and the boronias.

A Friends organisation has been invaluable in providing support for the 'nice to have' aspects of the centre such as interpretive signs, extension of the playground, art work and similar.

Information on the centre is available at www.redland.qld.gov.au.

The Wildlife Garden shows the potential for planting for wildlife in your own backyard. Photo: Jeanette Adams

Research Roundup

Bellairs, S.M., Bartier, F.V., Gravina, A.J. and Baker, K. (2006). **Seed biology implications for the maintenance and establishment of *Tetratheca juncea* (Tremendraceae), a vulnerable Australian species.** *Australian Journal of Botany* 54(1): 35-41.

Benson, D. and Eldershaw, G. (2005). **Naturalizing non-local native trees at Botany Bay: The long-term impact of historical plantings.** *Ecological Management & Restoration* 6(3): 163-171.

Bidwell, S., Attiwill, P.M. and Adams, M.A. (2006). **Nitrogen availability and weed invasion in a remnant native woodland in urban Melbourne.** *Austral Ecology* 31(2): 262-270.

Bussell, J.D., Hood, P., Alacs, E.A., Dixon, K.W., Hobbs, R.J. and Krauss, S. (2006). **Rapid genetic delineation of local provenance seed-collection zones for effective rehabilitation of an urban bushland remnant.** *Austral Ecology* 31(2): 164-175.

Lee, S.Y., Dunn, R.J.K., Young, R.A., Connolly, R.M., Dale, P.E.R., Dehayr, R., Lemckert, C.J., McKinnon, S., Powell, B., Teasdale, P.R. and Welsh, D.T. (2006). **Impact of urbanization on coastal wetland structure and function.** *Austral Ecology* 31(2): 149-163.

Neilan, W., Catterall, C.P., Kanowski, J. and McKenna, S. (2006). **Do frugivorous birds assist rainforest succession in weed dominated oldfield regrowth of subtropical Australia?** *Biological Conservation* 129(3): 393-407.

Noble, J.C. and Walker, P. (2006). **Integrated shrub management in semi-arid woodlands of eastern Australia: A systems-based decision support model.** *Agricultural Systems* 88(2-3): 332-359.

Oliver, I., Ede, A., Hawes, W. and Grieve, A. (2005). **The NSW Environmental Services Scheme: Results for the biodiversity benefits index, lessons learned and the way forward.** *Ecological Management & Restoration* 6(3): 197-205.

Pepper, C., McCann, L and Burton, M. (2005). **Valuation study of urban bushland at Hartfield Park, Forrestfield, Western Australia.** *Ecological Management & Restoration* 6(3): 190-196.

Proceedings of the Linnean Society of New South Wales. Volume 127. **The Biology and Ecology of Gibraltar National Park.**

Information resources and useful websites

Introductory Weed Management Manual

www.weeds.crc.org.au/documents/manual.pdf

This is a training resource for individuals or groups involved in weed management, produced by the CRC for Australian Weed Management and the Department of Environment and Heritage. The manual is suitable as a training aid for a wide range of users, such as private landholders, conservation groups, catchment management groups, industry, and local, state and territory governments. The Manual is an introductory guide for those with little experience with weed management, particularly the control of environmental weeds. It will be of use to those who wish to develop their own weed management knowledge and skills and as a training resource for those who need to train staff or volunteers in weed management techniques. As well as the pdf version, printed copies of the manual (available as a ring-binder folder) are available at no cost. Contact Nikki Ward, Vegetation Management Policy Section, Department of Environment and Heritage. Phone 02 6274 2082. Email nikki.ward@deh.gov.au

Grassy Box Woodland Conservation Management Network website

http://www.gbwcmn.net.au/index.shtml

The Grassy Box Woodlands Conservation Management Network (CMN) aims to co-ordinate the protection and ongoing management of remnants of Grassy Box Woodlands. It brings together sites and managers from across New South Wales. The website includes:

- about the Grassy Box Woodlands CMN;
- about Grassy Box Woodlands;
- monitoring Grassy Box Woodlands including templates and data storage;
- grassy Box Woodlands education resources;
- legislation, publications and useful links; and
- contacts.

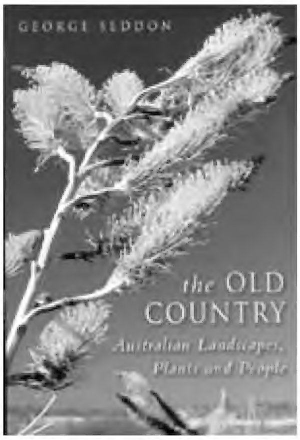
Australia's Biodiversity - Responses to Fire Plants, Birds and Invertebrates

http://www.deh.gov.au/biodiversity/publications/technical/fire/index.html

This Biodiversity Technical Paper has been available since 1999, but it a useful starting point. Includes: 'Biodiversity and fires: an Australia-wide perspective on plant-species changes after a fire event' by A. Malcolm Gill; 'Fire and Australian birds: a review', by J.C.Z. Woinarski; and 'Long-term effects of repeated prescribed burning on forest invertebrates: management implications for the conservation of biodiversity' by Alan York.

The Old Country: Australian Landscapes, Plants and People

George Seddon, October 2005, University of Western Australia, Perth



According to the publisher: "We are a nation of gardeners, and we take pleasure in tending our backyards. But this pleasure sits uneasily with our knowledge that the places where most of us live are running out of water. We suspect that our lawns and many of our plants from the damp climates of northern European gardens are too demanding of scarce supplies, but can't imagine our streets and gardens without them. The Old Country opens our eyes, and minds, to other possibilities. It does so by telling us stories about our natural landscape. The better we understand the delicacy and beauty of our natural environment, the more 'at home' we will feel as Australians. This passionate, wise and witty book, enriched with breathtakingly beautiful illustrations, suggests that the answers to our water problems lie here, at home. This book will help all Australians to change their attitudes towards native plants, promoting a wiser use of our scarce water resources". ISBN-13: 9780521843102; ISBN-10: 0521843103. 288 pages. RRP: $49.95.

Fire and Birds: Fire Management for Biodiversity

Supplement to Wingspan 15(3), September 2005

Recognising that fire is an essential natural force in Australia, this publication examines the affect of fire on birds, especially in relation to the management of the vegetation that is their habitat. Many birds are threatened by inadequate fire management. Biodiversity loss is considered to result from factors such as high fire frequency and intense broadscale fire but also fire exclusion. Maintaining a mosaic of habitats of different fire ages is recommended for large areas, but is problematic for small areas. Articles deal with birds and fire in different regions of Australia, and also in different habitats, such as Spinifex Grasslands and Mallee Heathlands. Wingspan is published by Birds Australia. http://www.birdsaustralia.com.au/wingspan.html.

Bushfire CRC

http://www.bushfirecrc.com/

The Bushfire Cooperative Research Centre is a collaborative venture established involving State fire and land management agencies, eight universities, CSIRO, federal government agencies including the Bureau of Meteorology, Emergency Management Australia and the Australian Building Codes Board, and New Zealand fire and forest research agencies. The Centre's objectives are to provide research which enhances the management of the bushfire risk to the community in an economically and ecologically sustainable way.

Southeast Queensland Fire and Biodiversity Consortium

http://www.gu.edu.au/school/asc/fire2/home.html

The Southeast Queensland Fire and Biodiversity Consortium has added the 'McArthur Forest Fire Danger Meter' to the extensive range of products and materials available on its website. The program can be accessed on http://www.gu.edu.au/school/asc/fire2/htmls/frame08_whatsnew.html.

Other useful resources include the 'Individual Property Planning Kit' which assists private landowners write and prepare fire management plans for their property, and the 'Strategic Manual' which assists local governments to plan and devise a city-wide fire management strategy. To download these and other documents visit http://www.gu.edu.au/school/asc/fire2/htmls/frame06_products.html.

ScienceNetwork WA

http://sciencewa.net.au

ScienceNetwork WA is an independent source of Western Australian science news and information. It aims to raise community awareness of the importance of science to our daily lives and the scientific principles at work in every day life, as well as encourage the uptake of scientific careers. The site contains breaking news from industry, educational and research institutions; a database of upcoming events; profiles of leading scientists, key scientific organisations, and top industry bodies; and links to many resources for students, teachers and professionals. For further information, contact: Phillipa Prior, phillipa@scitech.org.au.

ANPC Workshop

Workshop on the conservation and rehabilitation of grassy ecosystems in the ACT

29-30 November 2006, Canberra, ACT

Venue and field sites to be confirmed.

This two-day workshop will include:

- presentations on the ecological principles underlying successful rehabilitation and conservation management;
- field-based demonstrations and application of rehabilitation techniques; and
- essentials of monitoring to track progress and guide management decisions.

A strong field component will allow participants to work towards understanding a site, its current condition and threats, and the best approach to its rehabilitation and ongoing management.

Participants will benefit from the latest knowledge gained from research and practice by experienced local practitioners and grassy ecosystem managers.

Further details will be provided as they develop. Check the next *Australasian Plant Conservation*, the ANPC website and keep informed via the ANPC email list. If you are not on this email list and would like to be added, please notify the ANPC office.

Sally Stephens

anpc-sally.stephens@deh.gov.au
http://www.anbg.gov.au/anpc/course1.html

ANPC Email List - are you on it?

The ANPC runs an email list to keep you informed of events and issues relevant to plant conservation. We do not inundate you with emails, but send out occasional items of interest. ALL ANPC workshops are promoted via this network.

ANPC members are automatically added to the email list, but can be removed immediately on request. If, by chance, you are not on the list and would like to be, please send an email to anpc@deh.gov.au requesting we add you.

Your colleagues and friends are welcome to join the email list, even if they are not ANPC members.
All they need to do is to email us their request to subscribe.

The email list currently numbers over 1000 recipients nationwide, so this is an effective way to disseminate information regarding plant conservation.

To subscribe (or unsubscribe) or to post a message, email anpc@deh.gov.au

Conferences and Workshops

Australasian Bushfire Conference 2006

6 - 9 June 2006, Queensland

Hosted by Griffith University and Southeast Queensland Fire and Biodiversity Consortium. The conference theme is 'Life in a Fire-Prone Environment: Translating Science into Practice' and the event aims to provide a forum to share new ideas on the complex issues of bushfire management. The Conference encourages communication between agencies and groups involved in bushfire management, to build upon the lessons learnt from previous bushfire campaigns, to facilitate a new understanding of the role of fire in the landscape. Bushfire 2006 will be an opportunity to present and discuss multi-disciplinary practices, research and development in bushfire science. Topics will cover fire management in urban/rural interface, development controls, bushfires in a changing climate, fuels management, community involvement and participation in fire management, fire ecology, remote sensing, mapping, maintaining the balance between protection and conservation.

Further information: http://www.bushfire2006.com/.

Catchments to Coast

9-14 July 2006, Cairns, Queensland

The Society of Wetland Scientists (SWS) 27th International Conference and the Australian Marine Sciences Association (AMSA) Annual Meeting. International conference with major focus on the vital role and value of wetlands within the terrestrial and marine environments. The conference will be supplemented by a range of more specific wetland and marine science topics of current interest, including estuaries, aquaculture, migratory species, hydrological/geological processes, biogeochemistry, ecotoxicology, ecosystem-based management and protected areas.

SWS themes: wetlands and water quality, rejuvenation of damaged natural wetlands; biodiversity in wetlands; sustainability of managed and constructed wetlands; wetlands and global changes in climate and sea level; social, economic and political pressures on wetlands; indicators of change in wetlands - tools for managing change.

AMSA themes: catchments and corals - land-sea interactions in the tropics; catchments to Coasts - linking management and science; coastal geomorphology and geology; coastal oceanography; estuaries, fish, fisheries and aquaculture; marine education; threats to coastal environments; tropical and temperate marine ecology; water quality in Australian catchments.

More information: http://www.catchments.org.au.

Eighth International Mycological Congress

20-26 August 2006, Cairns, Queensland

Featuring 55 symposia and 8 pre-congress workshops, this will be the first International Mycological Congress held in the Southern Hemisphere.

Register online at:
http://www.sapmea.asn.au/conventions/imc8/index.html.

Evolution, Environment, Ecology & Botanic Gardens

15-17 September 2006, Cranbourne, Victoria

This is the Conference of the Association of Friends of Botanic Gardens. The Conference will focus on the evolution and ecology of our environment and the ongoing involvement of Friends of Botanic Gardens groups in these areas.

Further information: PO Box 151, Bulleen, Vic., 3105 or smartie@bigpond.com.

15th Australian Weeds Conference

24-28 September 2006, Adelaide Convention Centre

The Conference will be of particular interest to professionals and community representatives with an interest in weed science and management. The Conference theme is *Managing Weeds in a Changing Climate*. Proposed sub-themes include: political climate, funding climate, research climate, social climate, economic climate, environmental climate, climate change (global warming).

Further information:
http://www.plevin.com.au/15AWC2006/.

Discount subscription to *Ecological Management & Restoration* available to ANPC members

The ANPC has recently affiliated with the quarterly journal *Ecological Management & Restoration* (EMR) as both groups have compatible goals, aiming to improve communication and information exchange between practitioners and researchers working in ecosystem management and restoration.

Individual members of organisations affiliated with EMR are eligible for a discount subscription to the quarterly journal.

The special discount rate is $54.45 per year (normally $72.60) including GST. Overseas subscribers do not pay Australian GST. This discount is not available to groups or organisations.

To subscribe, simply tick the relevant box on the ANPC membership form. This can be downloaded from the ANPC website at http://www.anbg.gov.au/anpc/index.html or obtained from the ANPC office on request.

Ecological Management and Restoration 'aims to bridge the gap between the ecologist's perspective and field manager's experience. Publishing peer-reviewed articles, technical reports, news items, reviews and letters on the science and practice of ecosystem restoration and management, this innovative journal combines a highly readable style with scientifically credible material. *Ecological Management and Restoration* answers the growing need among land managers for reliable, relevant information and acknowledges the need for two-way communication in devising new hypotheses, sound experimentation, effective treatments and reliable monitoring.'

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Australian National Botanic Gardens, ACT

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Australian Government Department of the Environment and Heritage

Royal Botanic Gardens Melbourne

Government of South Australia Department for Environment and Heritage

ANPC PLANT CONSERVATION TECHNIQUES MANUAL NOW ON CD!

Plant Conservation:

approaches and techniques from an Australian perspective

Edited by: Claire L Brown, Fiona Hall & Jeanette Mill. Australian Network for Plant Conservation (ANPC), 2003.

This manual covers a comprehensive range of topics to be considered when undertaking conservation and ecological rehabilitation.
In his foreword, Carl Binning writes:
'The manual draws on the expertise of some of the leading exponents of practical conservation in Australia.
The techniques and methods have been tested and refined by a broad network of plant conservation practitioners.'

35 authors contributed to the manual, which includes 39 chapters contained in 11 modules:

- Principles and Ethics of Conservation
- References and Resources
- Conservation Instruments and Initiatives
- Getting Started: Information for Conservation
- Conservation in the Field
- Rehabilitation and Translocation
- Monitoring and Adaptive Management
- Ecological Communities
- Propagating Threatened Flora for Conservation
- Cryptogams
- Training

Context boxes, glossaries, key reading, cross-referencing, reference lists, web sites and author contact details complement the detailed information contained in each chapter.

The manual is now available on CD for $30. Stocks of the big ring-binder are running low; if you prefer this version, order now or risk missing out!

To Obtain Your Copy

Ring-binder price: $55 (+ $10 postage & handling within Australia). Price includes GST.
CD price: $30 (including GST, postage & handling).

Order forms available from http://www.anbg.gov.au/anpc/books.html or contact the ANPC National Office on phone 02 6250 9509, email anpc@deh.gov.au.

Australasian Plant Conservation

BULLETIN OF THE AUSTRALIAN NETWORK FOR PLANT CONSERVATION

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